SPECIFICATIONS

FOR

TWO HORIZONTAL DIRECT-ACTING

COMPOUND SCREW ENGINES

FOR

U. S. S. CHARLESTON,

OF 3,730 TONS DISPLACEMENT,

THE ENGINES, WITH THEIR AUXILIARIES OF 7,500 I. H. P.

UNDER FORCED DRAUGHT;

INCLUDING

BOILERS, SCREW PROPELLERS, AND ALL APPENDAGES AND APPURTENANCES COMPLETE, TOGETHER WITH A LIST OF TOOLS, INSTRUMENTS, AND DUPLICATE PIECES TO BE FURNISHED.

WASHINGTON:
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JOHN S. PRELL

Civil & Mechanical Engineer.

SAN FRANCISCO, CAL.

SPECIFICATIONS

FOR

TWO HORIZONTAL DIRECT-ACTING COMPOUND SCREW ENGINES

AND BOILERS

FOR A

VESSEL OF 3,730 TONS DISPLACEMENT.

Reference being had to the accompanying drawings forming part of these specifications.

GENERAL DESCRIPTION.

The engines will be placed in separate water-tight compartments, and will be duplicates; the low-pressure cylinder being forward of the high-pressure in the forward, and abaft it in the after compartment; the forward engine to turn the starboard propeller.

Each engine will have a high and a low-pressure cylinder of 44 and 85 inches diameter respectively, and a stroke of piston of 36 inches. The indicated horse-power to be about 7,500 under forced draught.

The high-pressure cylinders, covers, and bottoms are to be steam-jacketed with steam of boiler-pressure. The valve-chambers are to be cast on the cylinder-casings of both high-pressure and low-pressure engines. The stop-valves and throttles will be contained in separate castings, bolted to the high-pressure cylinder-casings. The main steam-valves will be of the piston type, two to each cylinder. The valve motion is to be of the radial type, as shown in the drawings, and arranged to effect a good distribution of steam, without distorting the exhaust, when cutting off steam between the limits of $\frac{1}{4}$ stroke and such a point as shall give the maximum power of the engines, as above specified, with steam in boilers at 90 pounds pressure per square inch.

JOHN S. PRELL
Chief of Mechanical Engineering

SPECIFICATIONS

FOR

TWO MONOLITE HEAVY-DUTY CRUDE OIL ENGINES

AND BOILERS

FOR

VESSEL OF 8750 TONS DISPLACEMENT

Each piston will have a single piston-rod, secured to a cross-head moving on straight guides of rectangular section, which will be bolted to the cylinder-casings at one end and to the crank-shaft pillow-blocks at the other. The crank-shafts are to be of steel, each in a single forging, with cranks at right-angles. The castings forming the crank-shaft pillow-blocks will be cast in one piece for each engine. They will be bolted to the engine-seatings, and stayed to the cylinders by steel tie-rods.

The condensers will be cylindrical, placed athwartship as shown, and will be made of sheet-brass, except the flanges, tube-sheets, and nozzles, which will be of composition.

The tubes are to be of brass. Each condenser is to have a cooling surface of not less than 6,750 square feet. The circulating water will pass through one-half of the tubes and return through the remainder; thence overboard through the outboard-delivery valves.

The circulating-pumps, one for each condenser, will be of the centrifugal type; each driven by its own engine direct, and so arranged as to be used for freeing the bilges in case of necessity.

The air-pumps, one for each condenser, will be horizontal; each worked by an independent, two-crank, compound engine. Each will deliver into a feed-tank in its engine-room.

There is to be a vertical double-cylinder feed-engine, with two double-acting pumps, in each fire-room, to be used as main feed-pumps. Their suction-pipes are to connect to feed-tanks, hot-wells, and bottoms of condensers only. Each of these pumps is to be arranged so as to be capable of feeding each boiler or any boiler.

A double-cylinder auxiliary engine, same as main feed-engines, with two double-acting pumps, is to be fitted in each fire-room, with a set of feed-pipes, feed-valves, and overflow-valves, separate and distinct from the pipes and apparatus belonging to the main feed-pumps. These pumps are to be fitted to draw water from the bottoms of the condensers, from the feed-tanks, from the sea, and from bilges.

There are to be two bilge-pumps worked by each air-pump engine, one drawing from the bilge valve-boxes and the other from the bilge. The propellers are to be right and left, three-bladed, of manganese-bronze, and of 14 feet diameter.

There are to be six main boilers, in two water-tight compartments, with athwartship fire-rooms; the boilers to be placed in opposite directions with their uptakes all leading to a common smoke-pipe. The boilers in the forward compartment are to be 11 feet diameter, and those in the after compartment 11 feet 6 inches diameter. They are to have, collectively, about 15,600 square feet of heating surface. The boilers are each to have three furnaces, and horizontal fire-tubes behind the furnaces leading from a combustion-chamber common to the three furnaces to a common uptake at the back end.

There will also be an auxiliary boiler, with 400 square feet of heating surface, on the protective deck over the forward main boilers.

There is to be one smoke-pipe, connecting with the uptakes of all the boilers, to be about 60 feet high above the highest grate-bars. The fire-rooms are to be arranged to work *in plenum*, air being driven into each fire-room by blowing-fans of sufficient power to maintain an air pressure of not less than 2 inches of water. The engines, main boilers, and steam-pipes to be entirely below the protective deck.

There will be steam starting and reversing-gear, distilling apparatus, auxiliary bilge and fire-pumps, ash-hoisting engines, a windlass for handling the anchors and for other heavy work, a steam winch for hoisting boats and other light work, steam turning-gear for main engines, and such other auxiliary or supplementary machinery, tools, instruments or apparatus as may be described in the following detailed specifications or shown in the official drawings.

DETAILED SPECIFICATIONS.

HIGH-PRESSURE CYLINDER-CASINGS.

The high-pressure cylinder-casing of each main engine, which will include the steam and exhaust ports and passages, inboard head, valve-chests, and sole-plate, is to be made of best cast-iron. It will be about $52\frac{3}{4}$ inches in outside diameter, with walls $1\frac{1}{4}$ inches thick, except at ends, where the thickness is increased, as shown in drawings. The inboard head will be $1\frac{3}{4}$ and 2 inches thick, will be ribbed on the outside, and will have the piston-rod stuffing-box nozzle cast on. There will be at the bottom a sole-plate 10 x $56\frac{1}{2}$ x $1\frac{3}{4}$ inches, well ribbed to body of cylinder, faced on under side, and having holes drilled for holding-down bolts. There will be, at inboard end of the cylinder-casting a flange from top to bottom, faced and drilled, for bolting to the low-pressure cylinder. There will also be a flange extending all around the high-pressure exhaust-nozzle, faced and drilled, for making the steam connection between the two cylinders. There will be a nozzle at lower part of head, with flange, for the relief-valve and drain-cock. There will also be on outside of casting the following facings, raised and ribbed where necessary, viz:

One for cylinder-cover;
Four for valve-chest bonnets;
One for throttle-valve;
One for auxiliary exhaust to receiver;
One for stuffing-box flange;
One for cross-head slide;
One for main tie-rod;
One for diagonal tie-rod;
Two for valve-motion rock-shaft brackets;
One for steam to jacket;
One for jacket drain;
Two for valve-chest drains;

One for receiver-drain;
Three for starting-lever brackets;
One for starting-valve chest;
Two for indicator attachment.

The casing will be bored to receive the cylinder-lining, as shown.

HIGH-PRESSURE CYLINDER-LININGS.

The working lining of each high-pressure cylinder will be made of cast-iron, as hard as tools can work. It will be $1\frac{3}{8}$ inches thick, turned and faced as shown. It is to be smoothly and accurately bored, in place, to a diameter of 44 inches for a length of 41 inches, and to a diameter of $44\frac{1}{2}$ inches for the remainder of the outboard end. It is to be inserted in the cylinder-casing in such a manner as to be steam-tight at both ends and at outboard steam-ports. The outer end is to come fair with the facing for cylinder-cover.

HIGH-PRESSURE CYLINDER-COVERS.

Each high-pressure cylinder-cover is to be made of best cast-iron, with double shell, well ribbed. It will be cored to form a man-hole and bored and faced for a man-hole plate. It is to be turned and faced to fit the cylinder-casing. It will have a lug for lifting by, and faced bosses for jacket steam and drain-pipes. The ribs are to have holes for the circulation of steam and drain-holes for water. Walls of covers to be $1\frac{1}{4}$ inches thick. Each cover to be secured to its cylinder by thirty-two $1\frac{1}{4}$-inch wrought-iron studs, with finished nuts.

HIGH-PRESSURE STEAM-JACKET.

The steam-jacket of each high-pressure cylinder will consist of the space between the cylinder-casing and cylinder-lining; also of the hollow of cylinder-cover. Steam to be taken from top or side of the main steam-pipe outside the engine stop-valve with a pipe leading to each jacket-space.

A stop-valve to be in each branch of pipe. Drain-pipes from the lowest parts of each space are to lead to an approved automatic trap, thence by independent pipes and valves to the feed-tank and bilge.

HIGH-PRESSURE VALVE-CHESTS.

Each high-pressure valve-chest will be fitted for two piston-valves of 13 inches diameter. There will be an opening at each end of each valve-seat for removing the valves and valve-chest linings. Each opening will have a single-plate cast-iron cover, as shown; each with a boss for an oil-cup, and with oil passages for lubricating the valve-stems. Each inboard cover will have a stuffing-box, as shown, with a grooved bearing for supporting the weight of valve. Each outboard cover will have a projecting cover for valve-stem, with a grooved bearing, boss for oil-cup, and oil passages, same as inboard cover. Each cover to be secured by ten $\frac{7}{8}$-inch studs and nuts. The valve-chests will be accurately bored and faced to receive the working linings.

HIGH-PRESSURE VALVE-CHEST LININGS.

There will be a working lining at each end of each high-pressure valve, made of cast-iron as hard as tools can work. Each lining will be turned and faced, and will be so inserted in the bore of the valve-chest as to make all joints steam-tight. The linings are to be kept in place by the valve-chest covers as shown. They will each be smoothly and accurately bored, in place, to a diameter of 13 inches.

HIGH-PRESSURE STEAM-PORTS.

The high-pressure steam-ports in valve-chest linings will be $3\frac{1}{2}$ inches wide. Each will contain six diagonal bridges, of dimensions as shown. The steam-passages leading to cylinders to be made as shown, and smoothly cored.

HIGH-PRESSURE PISTON-VALVES.

Each high-pressure piston-valve is to be made of tough cast-iron with followers of same. Each follower to be secured by four $\frac{3}{4}$-inch wrought-iron bolts, with T-heads, and with square composition nuts, locked as shown. The wearing and packing-rings to be of cast-iron. The packing-rings to be cut obliquely and tongued. All parts except the connecting trunk to be turned, bored, and faced. The inboard end of each valve to contain a wrought-iron ring, bored tapering, for a bearing for the valve-stem.

HIGH-PRESSURE VALVE-STEMS.

Each high-pressure valve-stem will be of forged steel, $3\frac{1}{2}$ inches diameter at stuffing-box. The inboard end will be formed into a bearing for the valve link-pin; fitted with brasses, cap, bolts, lock-nuts, and keepers. The stem will have a tapered bearing in the ring at inboard end of valve, and will be secured at the other end by a cast-iron sleeve, screwed on with left-handed thread. This sleeve is to be turned and to slide in the bearing in outboard cover to take the weight of the valve. The sleeve to be further secured by a round nut with right-handed thread, and by a split-pin keeper. A tool, as shown, to be furnished for screwing the sleeves on the valve-stems.

LOW-PRESSURE CYLINDER-CASINGS.

The low-pressure cylinder-casing of each engine, which will include the steam and exhaust-ports and passages, inboard-head, valve-chest, and sole-plates, is to be made of best cast-iron of sufficient hardness, consistent with strength, to form a working cylinder, without lining. It will be smoothly and accurately bored to an internal diameter of 85 inches for a length of 41 inches, leaving the walls $1\frac{3}{4}$ inches thick; the remainder of the outboard end being bored to an internal diameter of $85\frac{1}{2}$ inches. The inboard head will be $1\frac{3}{4}$ and 2 inches

thick, will be ribbed on the outside, and will have the piston-rod stuffing-box nozzle cast on, as well as a nozzle at the bottom for a 16-inch man-hole. There will be at the bottom of cylinder-casing two sole-plates, each 10 x $56\frac{1}{2}$ x $1\frac{3}{4}$ inches, well ribbed to body of cylinder, faced on under sides, and having holes drilled for holding-down bolts.

There will be flanges at inboard end and around the high-pressure exhaust-passage to match those on the high-pressure cylinder.

There will be on the outside of casing the following facings, raised and ribbed where necessary, viz:

One for cylinder-cover;
Four for valve-chest covers;
One for main exhaust-pipe;
One for stuffing-box flange;
One for man-hole plate;
One for cross-head slide;
Two for main tie-rods;
One for diagonal tie-rod;
Two for valve-motion rock-shaft brackets;
One for cylinder of reversing-engine;
One for reversing-engine throttle-valve casing;
One for reversing-engine exhaust connection;
One for receiver safety-valve;
Two for indicator attachments;
Two for starting-valve pipes;

BOLTING CYLINDERS TOGETHER.

The high-pressure and low-pressure cylinders of each engine are to be bolted together by $1\frac{1}{4}$-inch body-bound wrought-iron bolts and studs with finished nuts. When bolted together the faces of all sole-plates must lie accurately in one plane; and the axes of the cylinders must be parallel with each other, 6 feet 9 inches apart, and must, at corresponding points, be equidistant from sole-plate plane.

LOW-PRESSURE CYLINDER-COVERS.

The low-pressure cylinder-covers are to be similar in form, material, and manufacture to those of the high-pressure cylinders; but will have $1\frac{1}{2}$-inch walls, and will not be steam-jacketed. Each cover to be secured to its cylinder by 35 $1\frac{1}{4}$-inch studs with finished nuts.

LOW-PRESSURE VALVE-CHESTS.

Each low-pressure valve-chest will be fitted, in the same manner as the high-pressure chests, for two 26-inch piston-valves. Each valve-chest cover will have a boss for attaching an oil-cup, but the oil connections with valve-stem sleeves will be made by internal pipes instead of being drilled in the castings. Each cover to be secured by twelve $\frac{7}{8}$-inch studs and finished nuts. In making the outboard covers of both high-pressure and low-pressure valve-chests the detail drawings will be followed, and not the general plans of engines, which are in error.

LOW-PRESSURE VALVE-CHEST LININGS.

The working linings of the low-pressure valve-chests will be similar in material and fitting to those of the high-pressure engines; but will be cut short at the outer ends, and each will be secured in place by a wrought-iron ring, in sections, well bolted to the walls of the corresponding steam-nozzle. They will each be smoothly and accurately bored, in place, to an internal diameter of 26 inches.

LOW-PRESSURE STEAM-PORTS.

Each steam-port in the low-pressure valve-chest linings will be 5 inches wide. Each will contain 12 diagonal bridges as shown. The steam passages to be made as shown, and smoothly cored.

LOW-PRESSURE PISTON-VALVES.

Each low-pressure piston-valve is to be made of composition. The shell is to be $\frac{7}{32}$-inch thick at middle and $\frac{5}{16}$-inch at ends. The spiders for connecting with the valve-stem are to be cast separately and bolted in as shown. That at the inboard end will be bored to a sliding fit on valve-stem; that at the outboard end will carry a wrought-iron ring, bored tapering, to fit valve-stem. The packing of valves to be as shown in detail drawings.

LOW-PRESSURE VALVE-STEMS.

Each low-pressure valve-stem will be made of forged steel, $3\frac{1}{2}$ inches diameter at stuffing-box and 2 inches diameter between valve-spiders. It will have a $2\frac{1}{2}$-inch hole drilled axially in that part which is $3\frac{1}{2}$ inches diameter; this hole to have a screw-plug at end. The inboard end to be finished same as for high-pressure engines. The stem will have a tapered bearing in the ring carried by the outboard valve-spider, and will be secured in place by a composition sleeve screwed on with right-handed thread. This sleeve is to be turned, and to slide in the bearing in outboard cover to take the weight of valve. The sleeve to be further secured by a long tap-bolt screwed into valve-stem end with left-handed thread.

CYLINDER MAN-HOLE COVERS.

The man-holes in cylinder-covers are to have covers to fit bores and facings and recessed for the piston-bosses and nuts. They are to be of cast-iron, and will have facings for relief-valve flanges. The openings to relief-valves will be, for the high-pressure engines, 3 inches diameter, and for the low-pressure engines 6 inches diameter. The covers for the low-pressure inboard man-holes will be cored out as shown, with nozzles and facings for 6-inch relief-valves. All covers to be well secured by wrought-iron studs, and to be provided with forcing-bolts and eye-bolts; also to be so fitted that wedges may be used in breaking joints.

RECEIVERS.

The receiver of each engine will consist of the cored passages between the high and low-pressure valves. Each will be fitted with a spring safety-valve of approved design, with nickel seat, having an opening of 3 inches diameter and loaded to 40 pounds per square inch above atmospheric pressure.

CYLINDER CLOTHING.

The cylinder-casings, after being tested and secured in the vessel, are to be covered with approved non-conducting material and neatly lagged with black walnut all over. The lagging to be removable, in one piece, over each cylinder cover, man-hole cover, valve-chest cover, and starting-valve chest. The lagging elsewhere to be so secured as to be easily removed, replaced, and repaired.

MAIN PISTONS.

The main pistons are to be of cast-steel, $2\frac{3}{4}$ inches thick at boss and $1\frac{3}{8}$ inches at periphery. The followers are to be made of cast-steel, fitted to pistons, and secured by $1\frac{1}{8}$-inch T-headed wrought-iron bolts, with square composition nuts and approved keepers—10 for each high-pressure and 22 for each low-pressure piston. The packing-rings to be of cast-iron $1\frac{3}{8}$ inches thick, cut diagonally, tongued as shown, sprung in and turned to the diameters of cylinders. They are to be pressed out by springs of $\frac{3}{8}$-inch round steel in flat-sided spiral form, as shown—10 for each high-pressure and 20 for each low-pressure piston. A sheet-brass liner, resting on the packing-ring, will take the weight of each piston. These liners to be 22 inches long for the high-pressure and 32 inches long for the low-pressure cylinders. The pistons to be fitted to work steam-tight without undue friction. They are to be bored taper and parallel to receive the piston-rods, and faced for piston-rod nuts.

PISTON-RODS.

The piston-rods are to be forged of mild steel, and finished to a diameter of $7\frac{1}{4}$ inches. They are to be turned taper and parallel at ends to fit bores of pistons and cross-heads, and to have clearance in parallel part as shown. All piston-rods to be interchangeable. Each piston-rod to be secured to its piston by a wrought-iron nut with approved locking device, and to its cross-head by a recessed wrought-iron nut with steel set-screw and split-pin.

PISTON-ROD STUFFING-BOXES.

The main piston-rod stuffing-boxes and glands are to be of cast-iron with grooved composition bushings. Each gland to be adjusted by two composition nuts, made to turn in unison by means of composition pinions and spur-ring with cut teeth.

VALVE-GEAR.

The valve-gear is to be of the Marshall type, and must be adjusted to cut off steam, in forward gear, without distorting the exhaust or compression, between the limits of $\frac{1}{4}$ stroke and such a point as shall give the maximum engine-power, as above specified, when carrying steam in boilers at 90 pounds per square inch above the atmospheric pressure. The adjustment to be such that the points of cut-off at the two ends of each cylinder must not vary from each other outside of the following limits, viz:

Nominal cut-off, $\frac{1}{4}$; extremes, 0.24 and 0.26 stroke.
Nominal cut-off, $\frac{1}{2}$; extremes, 0.49 and 0.51 stroke.

The adjustment to also be such that no serious wire-drawing of steam shall take place at the grades of expansion above specified; also that the distribution of steam in backward gear shall be such as to allow the engines to be reversed quickly and to run astern at full power.

ECCENTRICS.

Each eccentric, of cast-steel, is to be made in two parts, fastened together by two $1\frac{9}{32}$-inch bolts. It is to be secured in its place on the shaft by a $1\frac{1}{4}$-inch steel tap-bolt screwed into the web of the adjoining crank. It is to fit its shaft snugly and to be turned accurately to an eccentricity of $2\frac{1}{4}$ inches, recessed at sides to fit the flanges of its strap.

ECCENTRIC-STRAPS AND LEVERS.

Each eccentric-strap is to be in two parts, of cast-steel, with brass bushings securely fitted and truly bored to fit its eccentric. The two parts are to be firmly fastened together by two $1\frac{9}{32}$-inch steel bolts with lock-nuts and keepers, and to be separated by brass chipping pieces. A prolongation of one part of each eccentric-strap will form the eccentric-lever, and will carry two steel pins for connection with the radius arm and valve connecting-rod. The former of these pins is to be surrounded by a steel bushing, securely pinned.

REVERSING-ARMS.

Each reversing-arm is to form part of the reversing quadrant common to each pair of engines, and is to be $16\frac{1}{2}$ inches between main centers.

RADIUS-LINKS.

Each radius-link, of forged-steel, is to have a closed end for the reversing-arm connection, with brasses and adjusting wedge. At the eccentric-lever end there will be brasses secured by a steel cap and bolts with lock-nuts and keepers. The distance between centers to be $16\frac{1}{2}$ inches.

VALVE CONNECTING-RODS.

Each valve connecting-rod, of forged-steel, is to be symmetrical as to its ends. Each end will have brasses secured by bolts with lock-nuts and keepers, the outer brass forming the cap. Each rod to be about 6 feet $1\frac{1}{8}$ inches between centers; the actual length to depend on adjustment of valve.

VALVE-MOTION ROCK-SHAFTS.

The valve-motion rock-shafts are to be made of steel, finished all over. The pins for valve-link and valve connecting-rod connections to be of steel, shrunk in and well secured. The details to be as shown in drawings.

VALVE-MOTION ROCK-SHAFT BEARINGS.

Each valve-motion rock-shaft will be carried in two bearings, each supported by a cast-iron bracket bolted to facings on the corresponding cylinder-casing. Each bracket to be further supported by a wrought-iron stanchion stepped on the engine bed-plate. The details of bearings to be as shown in the drawings.

VALVE-LINKS.

Each valve-link, of forged steel, will be finished at one end similar to the valve connecting-rod ends. This end to engage with the pin in arm on the valve-motion rock-shaft. The other end is to be forked, with a steel pin shrunk in, to connect with the valve-stem. Each link to be finished all over and to be about 9 inches between centers; the actual length to depend upon adjustment of valve.

REVERSING-QUADRANT.

The reversing-quadrants, one for each pair of engines, are to be made of cast-steel, cored out as shown. The main journals to be turned on the casting. The connections to radius-links and reversing-engines to be by means of pins, of forged steel, shrunk in and well secured.

REVERSING-QUADRANT BEARINGS.

Each reversing-quadrant will be carried in two bearings, the housings of which are to be cast on top of the middle pillow-block of the crank-shaft bearings. The bearings to be adjustable, as shown.

REVERSING-ENGINES.

Each reversing-engine will consist of a steam-cylinder with a hydraulic controlling cylinder. The steam-cylinder is to be bolted to a facing on the low-pressure cylinder-casing. The hydraulic cylinder, connecting-frame, and inboard head of steam-cylinder are to be in one casting, well secured to the steam-cylinder, and further supported by a wrought-iron stanchion stepped on the middle crank-shaft pillow-block. The steam-piston to have metallic packing. The steam piston-rod to be enlarged at the end to form a cross-head and to have a collar, into which the hydraulic piston-rod will be firmly screwed. The hydraulic piston-rod is to pass through both heads of its cylinder, and to be of equal diameter at both ends. The hydraulic piston and rod are to be packed with cup-leathers; spare leathers to be furnished. From the cross-head two connecting-rods will connect with the proper pins in the reversing-quadrant. The valve of the steam-cylinder will be of the piston pattern, of composition, working in a composition-lined valve-chest. There will be a bye-pass valve on the hydraulic cylinder which will conform to such drawings as may be furnished, or, failing this, to be of approved pattern; it will be worked by a continuation of the stem of the steam piston-valve. These valves will be worked by a system of differential levers, as shown—the primary motion being derived from the hand-lever at the working platform and the secondary motion from a pin on the reversing-quadrant. All parts to be so adjusted that the reversing-engine shall follow the motion of the hand-lever and be held firmly when stopped. There will be a throttle-valve in the steam-pipe to the reversing-engine and a cock in the bye-pass of the hydraulic cylinder; both of these to be controlled by one lever at the working-platform.

The reversing-engine will take steam from the main steam-pipe beyond the engine stop-valve and throttle; also from the auxiliary steam-pipe, and will exhaust into the low-pressure cylinder valve-chest at inboard end, or into escape-pipe, at will.

WORKING-PLATFORM.

There is to be a working-platform situated near each high-pressure cylinder, of such height that all working levers can conveniently be reached. The counter, revolution-indicators, clock, gauges, telegraph-dials, and other engine-room fittings are to be so placed near the working-platform as to be in full view while working the engines; speaking-tube mouth-pieces, and telegraph-levers to be conveniently placed.

WORKING-LEVERS AND GEAR.

There will be at each working-platform the following working-levers, viz:

One reversing-lever;

One throttle-valve lever;

One starting-valve lever;

All these to be fitted with spring-catches and notched sectors of "locomotive pattern."

One reversing-engine throttle-lever;

Four levers for cylinder and valve-chest drain-cocks.

There will also be a hand-wheel for working the throttle of the main pumping-engines; two hand-wheels for working the main steam-pipe stop-valves in the hydraulic engine-room; one for main stop-valve; one for bleeder-valve; one for starting-valve steam-pipe stop-valve; one for stop-valve in live steam-pipe to receiver.

CYLINDER RELIEF-VALVES.

There will be an automatic-spring relief-valve of 3 inches diameter at each end of each high-pressure cylinder, and one of 6 inches diameter at each end of each low-pressure cylinder. The springs must be long enough to allow the valves to open to their full extent without unduly increasing the load, and will have approved means of adjustment. The spindles against which the springs bear must fit loosely in sockets recessed in the valves, but will be so fitted that the valves can be moved

by the application of a lever. The valves are to be fitted with casings, which will prevent danger of people being scalded by hot water from the cylinders, and prevent steam and water from reaching the springs. Suitable fulcrums are to be on casings for the application of a lever for working the valves. One lever for this purpose to be supplied to each engine-room. All springs are to pass a satisfactory test.

CYLINDER DRAIN-COCKS.

There will be fitted to each end of each cylinder, at bottom, a drain-cock of approved design, with not less than 1¼ inches opening. These cocks to have bottoms cast in the shells and to be packed. They will have conical-pointed relieving-screws bearing against the bottoms of plugs to prevent setting fast. The cocks are to be operated by levers at the working-platforms. All the drain-cocks of each propelling-engine are to connect with a pipe of ample size leading, with a non-return valve, to the feed-tank or condenser, as may be directed. A branch of this pipe will lead to the bilge. The cock connecting the two branches must be such that one connection must always be open, but never both. Small drain-cocks to be in lowest parts of pipes.

Similar drain-cocks, to be worked from the working-platforms, will be fitted to the valve-chests.

STARTING-VALVES.

Each pair of engines will have a starting-valve, as shown in detail drawings. It will be bolted on facing on top of high-pressure cylinder, and will take steam by an independent pipe, with stop-valve, from the main steam-pipe beyond the engine stop-valve. Steam will be led from the starting-valve ports to each end of the low-pressure cylinder by a copper pipe, as shown in general plan. The starting-valve lever is to work in the same direction as the resulting motion of the low-pressure piston.

THROTTLE-VALVES.

There will be for each engine, bolted to high-pressure valve-chest, a throttle-valve of composition, as shown in drawings. It is to work freely when hot or cold, and be sufficiently tight to just supply steam to the engines when they are running at their lowest possible speed. It is to be worked by a lever, as above noted.

ENGINE STOP-VALVE.

Each engine stop-valve, contained in the same casting as the throttle-valve, is to be of the double-seated equilibrium pattern, and constructed entirely of composition It will fit loosely on its stem and be fitted with relieving-valves. It will be fitted to work, by bevel-gear, from the working-platform, and by universal joint, rods, and wheel from the main deck. The valve-casing will have, on the boiler side, facings for the following pipe-connections:

One for steam to reversing-engine;
One for steam to receiver;
One for steam to bleeder.

There will be attached, at bottom of casing, a drain-valve with pipe leading to feed-tank.

MAIN CROSS-HEADS.

Each main cross-head is to be of cast-steel, fitted to piston-rod as before described. It will rest on a cast-iron liner, as shown, working on the cross-head slide. The connecting-rod thrust, in backing, will be taken by a cast-iron box, ribbed, bossed, and fitted, as shown, to the cross-head, and secured by four $1\frac{3}{4}$-inch steel bolts with recessed nuts and set-screws. Each cross-head to have a wiper-oiling gear.

The cross-head journals are to be truly turned and faced, each $7\frac{1}{2}$ inches diameter and $8\frac{1}{8}$ inches long. A $1\frac{1}{2}$-inch hole is to be drilled axially from end to end of pins and bored tapering at ends, as shown.

CROSS-HEAD SLIDES.

The cross-head slides are to be of forged steel, finished all over. Each will be bolted to a bracket on cylinder-casing by two 2-inch body-bound steel bolts, and to a bracket on main pillow-block frame in a similar manner. Each slide, in the working part, will be rectangular, 21 x $4\frac{1}{2}$ inches in cross-section. Each to be grooved and otherwise fitted for lubrication as shown. All bearings to be true plane surfaces, and opposite sides to be parallel.

CONNECTING-RODS.

The connecting-rods will be made of wrought-iron, and, with all fittings, finished all over. They will conform to the detail drawings with the exception of the crank-pin binder-bolts. These bolts will be so fitted that the nuts will come at the cap end instead of as shown. The necessary alterations, to effect this change, in the connecting-rod ends, and caps, will be made in an approved manner.

The crank-pin brasses will be lined with white metal in strips, as shown.

All caps and brasses will be fitted with eye-bolts for handling.

The chipping pieces will be channeled for convenience in reducing them.

The crank-pin and wrist-pin brasses are to be faced with just sufficient end clearance to prevent nipping when heated.

CRANK-SHAFT PILLOW-BLOCKS.

The crank-shaft pillow-block for each pair of engines will be in one piece, of cast-iron, as shown in detail drawings.

The caps will be of cast-iron and snugly fitted to the jaws. The crank-shaft brasses will be lined with white metal in strips, and will be prevented from turning in their jaws by the binder-bolts being let partly into them.

The pillow-blocks of each pair of engines, after being secured in place in the vessel, will have their caps bolted on and the jaws and caps bored out to dimensions, accurately in line.

The brasses, after being fitted to their jaws and caps, will also be bored out in place. Holes, as shown, will be drilled in pillow-blocks and brasses, and tapped for the reception of the water-service pipes. The sole-plate of each pillow-block frame is to be faced to a true plane surface; also the brackets and bosses for cross-head slides and tie-rods, and the ends and sides of bearing-jaws. The crank-shaft brasses are to have just sufficient end clearance to prevent nipping when heated.

ENGINE-FRAME TIE-RODS.

The pillow-blocks of each pair of engines will be tied to the cylinders by three tie-rods of forged steel, 6 inches in diameter, as shown in detail drawings; also by two diagonal tie-rods of forged steel, about 4 inches in diameter.

Each tie-rod will have T-ends, and be secured by two forged steel bolts at each end. The bolts for the larger tie-rods to be as shown; those for the smaller ones to be of approved pattern and dimensions. The tie-rods and bolts to be finished all over. They will be fitted to their places after the cylinders and pillow-blocks have been lined up and secured in the ship. They are to bear squarely on their faces and to be a neat end-fit before their bolts are set up.

CRANK-SHAFTS.

The crank-shafts will be made of steel, each forged in one piece. The outside dimensions of the after half of each crank-shaft will be as shown in detail drawing No. 1,118. The forward half of each crank-shaft will be a duplicate of the after half, thus making the shafts reversible and interchangeable. The main and crank-pin journals will have holes drilled axially through them, these holes to conform to detail drawing No. 1,120, and not No. 1,118.

The crank-pin journals are to be accurately parallel to the shaft centers. All journals are to be smoothly and accurately turned, and, when finished, will be tested and their accuracy proved. The shafts to be finished all over. The bolt-holes in flange-couplings to be equally spaced, and drilled and reamed to template and gauge so that all flanges will fit indiscriminately.

CRANK-SHAFT COUNTERBALANCES.

Balance-weights of cast-iron with wrought-iron straps will be made and fitted to all crank-webs, as shown in detail drawings. They will be put in place on their respective cranks if required.

LINE-SHAFT.

The crank-shaft of the forward engines will be coupled to a section of line-shafting about 17 feet 3 inches long, of forged steel, hollow as shown and finished all over. The forward coupling is to be fitted to be bolted to either crank-shaft.

LINE-SHAFT PILLOW-BLOCK.

The line-shaft above mentioned will rest, at about the middle of its length, in a pillow-block as shown. This bearing to be made of cast-iron with white-metal lining. The holding-down bolts are to have clearance as shown, to allow for adjustment.

THRUST-SHAFTS.

The thrust-shafts will be of forged steel, each in one piece about 26 feet $5\frac{1}{2}$ inches long, to conform to detail drawing. To be finished all over, accurately fitted to adjoining shafts, and to be interchangeable.

THRUST-BEARINGS.

The thrust-bearings to be as shown; to be securely bolted to their seatings and to be adjustable in the fore-and-aft direction. The lower part of bearings to be lined with composition.

The thrust-rings to be of composition, easily removable, and fitted for ahead-thrust only. A tube and wick-holder to lead from oil-cups to each thrust-collar.

All pipe and valve-connections to water spaces are to be fitted complete, the inlet-pipes to connect with engine-room water-service and the outlets running to engine-room bilge. The thrust-rings to bear equally against all thrust-collars on shaft.

THRUST-SHAFT PILLOW-BLOCKS.

Each thrust-shaft will rest in a pillow-block in the forward part of shaft-tunnel. These are to be the same as the line-shaft pillow-block above mentioned.

PROPELLER-SHAFTS.

The propeller-shafts are to be of steel, forged in one piece, hollow, and fitted as shown. They are to be about 50 feet long, finished all over, covered with composition in all bearings, accurately fitted to propellers and to thrust-shafts, and to be interchangeable. The connections with thrust-shafts will each be by tapered end and socket with steel feather-keys, accurately fitted, and with screwed collar and studs, as shown in detail. Forcing-bolts to be fitted for starting the propeller-shafts out of thrust-shaft sockets. The after-end of each shaft is to be turned taper to fit the bore of propeller-boss, and to be fitted with steel feather-key, backing-nut, keeper-pin, and water-tight plug as shown. The composition coverings are to be securely shrunk on and pinned in place, and to be water-tight and accurately and smoothly turned.

STERN-TUBE BEARINGS.

Each propeller-shaft will rest in three bearings, of lignumvitæ on end of grain, in the stern-tube. The lignumvitæ of each bearing is to be held in a composition sleeve, with strips to prevent its turning, and provided with passages for the circulation of water. The forward sleeve will be contained in

a cast-iron sleeve which will be inserted from inside the vessel, and will include the stuffing-box casing. It will rest at its outboard end in a cast-iron ring in the stern-tube. The middle and after-bearing composition sleeves will be contained in an internal tube of cast-steel, made in two parts and flush-riveted together as shown. It will be inserted from aft, and will be centered in the stern-tube by three rings, or sleeves, of cast-iron. It will be turned on the outside where it fits these sleeves, and will be bored inside for the insertion of the composition sleeves. This tube, after insertion, will be secured by a screwed cast-iron collar and by a wrought-iron tube extending forward to the sleeve of shaft-bracket, to which it will be fastened by countersunk screws. All the composition sleeves will be secured in place in an approved manner. All lignum-vitæ bearings are to be smoothly and accurately bored, with perfect alignment of shaft when in place. All dimensions to be as shown in detail drawing. A sleeve is to be fixed on after-end of each stern-tube to form a smooth water-line from the tube to the boss of propeller.

STERN-PIPE STUFFING-BOXES.

The stuffing-box of each stern-pipe will consist of the forward part of the cast-iron sleeve containing the forward bearing. A loose composition ring will form the bottom of the box. The gland will be of cast-iron with composition bushing, and will be provided with bolts and nuts as shown. There is to be a drain-cock for each stuffing-box with pipe leading to engine-room bilges.

SCREW-PROPELLERS.

The screw-propellers are to be made of manganese bronze, as shown. The starboard propeller to be right-handed and the port propeller left-handed. They are to be 3-bladed, 14 feet in diameter, and are to conform to the detail drawings. The blades are to be firmly and securely fitted on their bosses.

The hand-holes in bosses to be provided with flush covers, dovetailed and pinned. The cap on after end of each boss to be bolted securely and water-tight. The blades are to be cast as smooth as possible and to have any roughness removed. The bosses are to be finished all over. They are to be neatly fitted on propeller-shafts and securely fastened, as before described. The joint between shaft-casing and boss to be water-tight.

SHAFT-COUPLINGS.

All flange couplings on engine-shaft are to be forged on, turned $23\frac{1}{2}$ inches in diameter, and faced $2\frac{3}{4}$ inches thick. Bolt-holes are to be drilled to template and gauge to make shafts interchangeable. All bolts to be neat-fitting and interchangeable.

CONDENSERS.

The shells of condensers are to be made of sheet-brass or Muntz metal, with composition flanges, tube-sheets, stiffening-rings, and nozzles. The condensers to conform to the detail drawings. In each condenser a composition casting, forming a part of the shell, will contain the following nozzles with flanges properly faced, viz:

One for attachment of main exhaust-pipe;

One for suction-pipe of air-pump;

One for jet injection-pipe;

One for exhaust from main pumping-engines;

One for auxiliary exhaust-pipe;

Three for man-holes and hand-holes;

One for branch from auxiliary steam-pipe for boiling water in condenser;

One for attachment of soda-cock.

There will also be two faced brackets for securing the condenser to engine-room bulkhead.

The longitudinal shell-seams are to be strapped, riveted, and calked. The tube-sheets are to be drilled, tapped, and fitted with glands for packing the tube ends; the glands to be

beaded at outer ends to prevent tubes from crawling. The tube-plates are to be secured to angles on shell by collar-bolts, which will also be used for fastening the circulating-water chests. The chest for entrance and exit of condensing water is to be of composition, as shown, with division in middle, and with a man-hole in each compartment. The chest at the other end is to be formed by a curved sheet-brass bonnet with composition flange, man-hole ring, and man-hole plate, with stays as shown. There are to be 3,092 solid drawn brass tubes, No. 19 B. W. G., $\frac{5}{8}$ inch diameter outside; also six brass stay-tubes, No. 11 B. W. G., and 1 inch diameter. Supporting and baffle-plates to be fitted where shown, and secured in an approved manner. The condensers must be perfectly tight in all joints, and be so proved after being secured in place. Each condenser will be supported from underneath in an approved manner, but not suspended from deck as shown in the general plans. Also to be secured to engine-room bulkheads by the brackets before mentioned. A cock, pipe, and tank to be fitted to each condenser for the purpose of admitting an alkaline solution into the exhaust passages. Drain-cocks to be provided with pipes leading to bilges. A pipe is to connect the steam side of each condenser with the engine-room water-service for the purpose of filling the condenser when it is desired to clean the tubes by boiling. The steam for this purpose is to be introduced from the auxiliary steam system at the bottom of condenser. Man-hole plates are to be fitted with forcing-bolts and eye-bolts. Main bonnets to have lugs for handling by.

MAIN EXHAUST-PIPES.

Each low-pressure cylinder-casing will be connected with its condenser by a short pipe of copper, with composition flanges, and with expansion-ring as shown.

AIR-PUMPS.

Each condenser will have one air-pump, to be made of composition. It is to be of the half-trunk type, with horizontal cylinder of 24 inches bore and 15 inches stroke. The piston is to have approved metallic packing. The stuffing-box to have a spur-ring and pinions for setting up bolts equally. Valves are to be of India rubber with composition guards. The suction side of pump to be connected with condenser by a square composition trunk. All joints to be very carefully made. Each pump is to maintain a vacuum of within four inches of mercury of the weather barometer with the main engines at full power under forced draught. The pumps are to be well secured to the seatings provided, and will support on their sides the main bilge-pumps. Each air-pump will be worked direct by a horizontal, direct-acting, compound-engine as described below.

MAIN PUMPING-ENGINES.

Each main pumping-engine will have a high-pressure cylinder of 14 inches diameter and a low-pressure cylinder of 28 inches diameter with a stroke of 15 inches. The cylinders to be of close-grained cast-iron, bolted together as shown. The pistons to be of cast-steel, with cast-iron packing-rings. The slide valves to be of cast-iron with springs and plates on backs. Piston-rods and valve-stems are to be of forged steel; connecting-rods of wrought-iron; crank-shafts of forged steel, with cranks of cast-steel shrunk on; eccentrics of cast-iron; eccentric straps and levers, composition; radius links, wrought-iron; valve-connecting rods, wrought-iron; cross-heads, cast-steel. The piston-rods will extend through the cylinder-covers to work the air and bilge-pumps, the extension of the high-pressure rod being cased with composition. The crank-shaft bearings to be lined with white-metal. All parts are to be finished similarly to corresponding parts of the main engines. Each engine is to take steam from the auxil-

iary steam-pipe, the throttle being worked from the working-platform, and to exhaust into its condenser by a special exhaust-pipe. The cylinders to be clothed the same as for main engines.

MAIN BILGE-PUMPS.

There will be two main bilge-pumps, with plungers $8\frac{3}{4}$ inches diameter, worked off each main pumping-engine direct, being connected to the low-pressure piston-rod in an approved manner. They will be made of composition throughout, with India-rubber valves. One of the pumps in the after engine-room will take suction from the main bilge valve-boxes and the other from the engine-room bilge direct. One of the pumps in the forward engine-room will take from the main bilge valve-boxes or from the double-bottom valve-boxes at will, and the other from the engine-room bilge direct. Each pair of bilge-pumps will discharge through a Kingston valve on the sea side of the air-pump discharge-valve. There will be a stop-valve in the discharge-pipe of each pump of each pair.

CIRCULATING-PUMPS.

The circulating-pumps, one for each condenser, will be of the centrifugal type, of composition. They will have fans of 32 inches diameter, and inlet and outlet pipes of 14 inches internal diameter. Each pump will be securely bolted to its engine and to the seating provided for it. Each pump is to be fitted to draw from the sea, the main bilge-pipe, or the bilge of its engine-room at will, and to discharge through the condenser-tubes or to the sea direct by a special outboard valve. The pump-chambers, passages, and fans to be smoothly cored and any roughness removed. An air-cock to be fitted to the highest part of each pump.

CIRCULATING-PUMP ENGINES.

Each circulating-pump will be driven by a vertical inverted cylinder direct-acting engine, as shown in outline in drawing No. 1,114. Each engine to have a cylinder of 9 inches bore

and 8 inches stroke, clothed and lagged. The valve-gear and other details are to be such that the engine shall be able, with ease, to supply sufficient condensing water when the main engines are at full power. They will be provided with fly-wheels of approved dimensions. Each engine will take steam from the auxiliary steam-pipe and exhaust into either auxiliary exhaust system at will.

PIPE CONNECTIONS OF CIRCULATING AND AIR-PUMPS.

From the main injection-valve in each engine-room a 14-inch copper pipe with a full-way sluice-valve in it will lead to the circulating-pump. A 10-inch branch from this pipe, with a sluice-valve in it, will lead to two non-return valves, one of which controls the suction from the main bilge-pipe and the other from the engine-room bilge. The water leaving the pump will pass into the chamber of a two-way valve, by means of which it can be directed to the condenser or overboard. A 14-inch pipe will lead from this valve to the condenser. From the condenser a pipe of same size will lead overboard through the outboard delivery-valve.

Each air-pump will take suction from the condenser only, as before described. It will discharge, by a 12-inch pipe, into the chamber of a spring-loaded valve leading overboard. A 5-inch branch from this pipe will lead to the feed-tank in the same engine-room, with a stop-valve at tank. There will be a branch of the auxiliary feed-pump suction system connected to the hot-well of each air-pump, and another to the channel-way beneath the air-pump foot-valves, each with a stop-valve.

MAIN INJECTION-VALVES.

The main injection-valves are to be of the Kingston type, with outside threads on stems, and each to have a 14-inch opening. They are to be secured to skin of ship and covered by rectangular gratings with inclined bars as shown in detail. Valves, nozzles, and gratings to be of composition.

INJECTION SLUICE-VALVES.

The sluice-valves in main injection-pipes are to be as per detail drawings. The sluice-valves in bilge-injection pipes to be similar to the above, but with 10-inch clear openings.

BILGE INJECTION-VALVES.

The bilge injection-valves, two for each engine-room, are to be non-return valves with screw-down stems and hand-wheels. To be made of composition and to be of approved pattern.

CIRCULATING-PUMP DELIVERY-VALVES.

The circulating-pump delivery-valves are to be double-faced, each with two seats. Each valve to be cast on its stem, and to have the screw-thread underneath the valve. The valves to conform to detail drawing, except that the hand-wheels are to be of composition, finished; instead of cast-iron as shown.

MAIN OUTBOARD DELIVERY-VALVES.

The outboard delivery-valves for condensing water are to be of composition, of the non-return type, all as per drawings; each with a copper key, secured near valve by a small brass chain.

MAIN BILGE DISCHARGE-VALVES.

When using the circulating-pumps for freeing the bilges, the water will be discharged overboard from each pump through a 10-inch non-return valve as shown in drawings.

The outboard discharge-valves of the main bilge-pumps will be of the same pattern as the above, but of 6 inches opening only. All to be of composition.

AIR-PUMP DISCHARGE-VALVES.

The outboard discharge-valve of each air-pump is to be a non-return valve of 12 inches diameter, opening downward, with an adjustable steel spring to keep it on its seat. All, except spring, to be of composition.

JET-INJECTION.

The jet-injection sprinklers are to be as shown on drawings of condenser. The injection water for each condenser is to be taken from a $4\frac{1}{2}$-inch Kingston valve, bolted to the nozzle of the main injection-valve by a $4\frac{1}{2}$-inch copper pipe, and to have a stop-valve close to condenser.

FEED-TANKS.

There will be a feed-tank in each engine-room, on starboard side close to dividing bulkhead. They are to be made of $\frac{1}{4}$-inch wrought-iron, to fit side of ship, and to be securely fastened in an approved manner. Each to have a 15 x 12-inch man-hole and plate on inboard side. The tanks are to be connected by a 4-inch pipe with a valve in each engine-room. Each tank to have the following pipe connections, viz: Discharge from air-pump, with valve; overflow-pipe leading to bilge, with end in sight; suction to feed-pumps, with valve. The tanks to be as shown in drawings, with zinc slabs properly suspended. Each tank will have a glass water-gauge, and a regulating valve in the supply-pipe, both of approved design.

FORWARD BOILERS.

Each boiler in the forward boiler compartment is to be 11 feet mean diameter and 19 feet 3 inches long, with 52 stay-tubes and 310 plain tubes. The furnaces are to be $42\frac{1}{2}$ inches internal diameter and 7 feet 6 inches long.

AFTER BOILERS.

Each after boiler is to be 11 feet 6 inches mean diameter and 19 feet 3 inches long, with 62 stay-tubes and 402 plain tubes. The furnaces are to be $44\frac{1}{2}$ inches internal diameter and 7 feet 6 inches long.

BOILER MATERIAL.

All material used in the construction of boilers, except the tubes, is to be open-hearth steel. The tubes are to be of the best wrought-iron.

BOILER-SHELLS.

The shell of each boiler will be made in three rings of $\frac{11}{64}$-inch plates.

BOILER-HEADS.

The front head of each boiler is to be made of two plates—the upper $\frac{7}{8}$ inch, and the lower $\frac{21}{32}$ inch thick; the latter flanged inwardly at the furnaces, and both together flanged inwardly at circumference. The back head will be $\frac{7}{8}$ inch thick in top plate and $\frac{11}{16}$ in the bottom plate, which will form the back tube-sheet. The back head to be flanged inwardly at circumference.

BOILER TUBE-SHEETS.

Each back tube-sheet will be as above specified. Each front tube-sheet will form the back of combustion chamber, and will be in one piece, $\frac{11}{16}$ inch thick. The tube-sheets are to be drilled for stay-tubes and plain tubes as shown, and they will be tapped for the stay-tubes in place. All tube-holes to be slightly rounded at edges.

BOILER-TUBES.

The plain tubes are to be lap-welded, 7 feet $3\frac{3}{4}$ inches long, 3 inches diameter outside, and swelled at back ends to $3\frac{1}{16}$ inches diameter. They are to be No. 10 B. W. G.

The stay-tubes are to be 7 feet $4\frac{1}{4}$ inches long, 3 inches diameter outside, and swelled at back ends to $3\frac{1}{4}$ inches diameter. They are to be $\frac{5}{16}$ inch thick. The small ends are to be screwed for $1\frac{1}{2}$ inches and the large ones for 3 inches. Each tube is to have a nut $\frac{3}{4}$ inch thick at back end. The threads on tubes are to be cut in such a manner as to accurately agree with those in tube-sheets. The stay-tubes are to be set up to a hard bearing in threads in front tube-sheet and to be made tight at back ends by their nuts. Other tubes are to be expanded by approved expanding tools.

BOILER BRACES.

Each boiler is to have 18 stays from head to head and 8 from front head to combustion-chamber, of dimensions shown. All these stays to have raised threads on ends and to be nutted inside and outside the plates. The bottoms and sides of combustion-chambers are to be stayed by $1\frac{3}{8}$-inch screw stay-bolts, spaced as shown, and nutted on both ends. The tops of combustion-chambers are to be stayed to tops of shells each by 44 braces $1\frac{1}{2}$ inches diameter. These braces to be pinned to T-irons riveted to shells and to eye-bolts screwed into tops of combustion-chambers and nutted both sides. All braces are to be made without welds.

RIVETED JOINTS.

The longitudinal joints of boiler-shells, two in each ring, are to be lapped $9\frac{5}{8}$ inches and quadruple-riveted as shown. Circumferential seams and seams in heads to be double-riveted, staggered; all others to be single-riveted. All rivets to be of steel. Rivet-holes to be drilled in place wherever possible; all others to be punched $\frac{1}{8}$ inch small and reamed in place, or else drilled fair after bending. All seams to be calked on both sides. Longitudinal seams are to break joints as shown.

MAN-HOLES AND PLATES.

There are to be two man-holes in the shell of each boiler, two in each front head and one in each back head, as shown. All holes to be stiffened by $\frac{3}{4}$-inch plates riveted on. Man-hole plates and fittings are to be of approved pattern and truly fitted. They will all be provided with conveniences for handling.

FURNACES.

Each furnace is to be made of two $\frac{1}{2}$-inch plates. Each ring is to be welded longitudinally; the two rings to be joined by a flange-joint with an Adamson ring. Furnaces are to be secured to front heads and to combustion-chambers by single-riveting with joints, as shown. The furnaces are to be perfectly circular in cross-section at all points.

FURNACE FRONTS.

Furnace fronts are to conform to such drawings as may be furnished. Failing this, they will be made with channel-iron frames, each covered with a $\frac{1}{4}$-inch wrought-iron plate on inside and a $\frac{3}{8}$-inch wrought-iron plate on outside, stayed where necessary and perforated for air entry where directed. The dead plates to be of cast-iron. Fronts to be fitted to furnaces so as to be easily removable.

FURNACE-DOORS.

Furnace-doors are to conform to drawings, if furnished. Otherwise to be as follows: To be made of $\frac{1}{4}$-inch wrought-iron plates, flanged one inch deep at edges to fit furnace fronts. To be provided each with a perforated inner plate secured by rivets and thimbles. To have wrought-iron hinges and latches. To have air-regulators in outside plate. On each side of each furnace-door in furnace front there will be a slice-bar opening with hinged cover on outside.

ASH-PIT DOORS.

Ash-pit doors of wrought-iron of approved pattern are to be fitted snugly to all ash-pits. They are to be provided with proper fastenings and with wrought-iron handles, catches, and hooks for handling, and for suspending them on bulkheads when not in use.

BRIDGE-WALLS.

Bridge-walls are to be made of cast-iron, well ribbed. They will be finished with fire-brick, and are to be so fastened to furnaces as to be easily removable. Each will have, below the grate-bars, a door as large as convenient, so fitted as to be easily opened from fire-room.

GRATE-BARS AND BEARERS.

The bearer-bars are to be of cast-iron; three for each furnace. Each will rest in two lugs riveted to furnace-plates. The grate-bars are to be of wrought-iron and to conform to detail drawings. Proper tools for shaking the grate-bars, one for each boiler, are to be provided.

COMBUSTION-CHAMBERS.

The combustion-chambers are to be made of $\frac{3}{6}\frac{5}{4}$-inch plates at top, sides, and bottom. Front plates to be $\frac{1}{1}\frac{1}{6}$-inch, riveted to furnaces and side-plates as shown. Tube-plates to be as before specified.

HANGING-BRIDGES.

There will be in each combustion-chamber a hanging-bridge as shown in outline in drawings. They are to be substantially constructed, and will be of such material and pattern as may be approved.

UPTAKES.

The uptakes are to be double, with $\frac{3}{16}$-inch inner plates and $\frac{1}{8}$-inch outer plates. They are to be built on $1\frac{1}{2}$ x $1\frac{1}{2}$ x $\frac{3}{16}$ inch angles, and the sides are to be secured to each other and to the boilers by $1\frac{3}{4}$ x $1\frac{3}{4}$ x $\frac{1}{4}$ inch angle-irons. The inner and outer plates are to be held together by $\frac{1}{2}$-inch bolts, and stayed by thimbles. Where the uptakes are exposed to flame there will be an inner plate of $\frac{1}{8}$-inch wrought-iron, held off about $1\frac{1}{2}$ inches from the inner plate of double shell by thimbles and rivets. The space between the inner and outer plates first mentioned is to be filled with silicate cotton. The uptakes of forward and after boilers are to be separate up to a short distance above the main deck, where they will be united. Above the smoke-pipe hatch, an oval jacket, with a 6-inch annular space, will surround the smoke-pipe for 2 feet 3 inches, and be covered by a hood with sufficient opening for the escape of hot air. There will be plates in uptakes, as shown, to protect the ends of boiler-braces.

UPTAKE DOORS.

The uptake doors are to be constructed the same as walls of uptakes where in contact with flame. They will be in four parts for each boiler, double-hinged as shown. They will be provided with wrought-iron hinges and latches of approved pattern.

DAMPERS.

There is to be a damper in uptakes for each boiler. These are to be so fitted as to be easily worked from their respective fire-rooms. They will conform to detail drawings, if furnished. Otherwise they will be made of such pattern as may be submitted by the contractor and approved.

SMOKE-PIPE.

There is to be one smoke-pipe, flat-sided, with rounded ends, 60 feet in total height above the upper grate-bars. It is to be made of $\frac{3}{16}$-inch wrought-iron, with all joints butted and strapped, and is to be fitted with internal stiffening stays as required. The pipe is to be provided with eyes, stays, and shackles of approved dimensions and pattern, and is to be so supported as to relieve the uptake of its weight. It is to be finished at top by a ring of flat and half-round iron, as shown.

A permanent ladder reaching to the top of the pipe on the outside is to be fitted as directed. From the top of uptakes to a short distance above the upper deck the shell of the pipe will be double and filled with silicate cotton the same as uptake casings. Four single-sheaved blocks to be fitted on top rim of pipe for slinging painters.

BOILER-SADDLES.

Each main boiler will rest in three saddles, which are to be built in and form part of the hull. The boilers are to be fastened to these by double angle-irons riveted to shells and saddles.

BOILER ATTACHMENTS.

Each main boiler will be provided with the following attachments, viz:

One steam stop-valve;
Two dry-pipes;
One main feed check-valve with internal pipe;
One auxiliary feed check-valve with internal pipe;
One surface blow-valve with internal pipe;
One bottom blow-valve;
One pumping-out valve;
Two safety-valves;
Two steam-gauges;
Two glass water-gauges;

Four gauge-cocks;
One sentinel-valve;
One salinometer-pot;
Two drain-cocks;
One air-cock;
Two hydrokineters or equivalent;
One cock with thread for the attachment of a syringe;
Circulating tubes.

All external fittings are to be of composition, and all details of which drawings are not furnished are to be of approved designs. No fittings are to be screwed into boiler-plates, but will be flanged and through-bolted, or secured in other approved manner. All cocks and valves will have spigots passing through boiler-plates. All screw valve-stems are to have outside threads.

CHECK-VALVES.

Main and auxiliary check-valves are to be $2\frac{1}{2}$ inches diameter, and each to have the discharge nozzle entirely above the valve when fully open. Valves are to have wing-guides, and suitable springs on top. They will have internal feed-pipes attached as shown.

BOTTOM BLOW-VALVES.

The bottom blow-valves are to be 2 inches diameter. They will be placed as shown on drawing No. 1,977, and not as shown on No. 1,746. Their hand-wheels must not project beyond the walls of the firing-troughs of central furnaces.

SURFACE BLOW-VALVES.

The surface blow-valves are to be 2 inches diameter, and each will have an internal pipe terminating in a dish as shown, which is to be about one inch above the highest heating surface.

PUMPING-OUT VALVES.

The pumping-out valves are to be similar to bottom blow-valves before specified.

BOILER STOP-VALVES.

The boiler stop-valves are to be self-acting, with stems placed horizontally, and to be fitted with gear as shown for working from the fire-rooms. Valves to be 9 inches diameter.

DRY-PIPES.

Each boiler is to have two brass dry-pipes of 7 inches internal diameter. They will be made with transverse slits for admission of steam, and are to be closed at their inner ends. They will be bolted to a double nozzle as shown, which in turn is to be bolted to front head of boiler by the same bolts that hold the stop-valve. The pipes to be supported in an approved manner.

SAFETY-VALVES.

Each boiler is to have two $4\frac{5}{8}$-inch safety-valves on one nozzle. They are to be as shown in detail drawings. Each valve to be fitted with gear, as shown, for working from fire-room or from main deck at will. The valves are to be set at a pressure of 95 pounds per square inch. Each valve is to be furnished with washers for the reduction of pressure to 65 pounds per square inch by decrements of 10 pounds each, each washer being marked with the number of its valve and with the pressure for which intended. Each valve is to have a suitable lock. All locks are to be alike and but one key to be furnished, suitably marked. Each safety-valve is to have a drain-pipe attached at least $\frac{1}{2}$ inch below the seat, and leading to bilge.

SENTINEL-VALVES.

Each boiler is to have upon its front a sentinel-valve of $\frac{1}{2}$ square inch area. Each valve to be fitted with a sliding weight and notched lever graduated to 150 pounds pressure, and not with spring as shown in drawings.

WATER-GAUGES.

Each main boiler is to have two glass water-gauges attached as shown. The pipes leading to tops and bottoms of boilers are to be $1\frac{1}{2}$ inches internal diameter, with valves of same size. The top, bottom, and blow-out cocks of each gauge are to have at least $\frac{1}{2}$-inch openings, and are to be closed-bottom gland-cocks of approved pattern, and not as shown in detail drawings. Cock-handles to be at least 6 inches long, and to hang downward in working position. The lowest exposed part of glasses to be about 1 inch below the highest heating surface. Blow-out cocks to have drain-pipes with union-joints. The gauge-glasses to be well protected.

GAUGE-COCKS.

There will be four gauge-cocks on each boiler, spaced about 4 inches vertically, the lowest cock being about 4 inches below the highest heating surface. These cocks to be of approved pattern and to have drip-pans and drain-pipes.

STEAM-GAUGES.

There will be two Lane's improved spring steam-gauges of $8\frac{1}{2}$ inches face for each boiler, placed where directed; one graduated to 100 lbs. and the other to 200 lbs. Each is to have a three-way cock and a coupling for application of test-gauge. Each gauge to have a separate attachment to boiler.

SALINOMETER-POTS.

Each boiler will have a salinometer-pot of approved pattern, with proper connections, fitted where directed.

BOILER DRAIN-COCKS.

Each main boiler will have at each end a $1\frac{1}{4}$-inch asbestos-packed drain-cock of approved pattern.

BOILER AIR-COCKS.

Each main boiler will have a $\frac{1}{2}$-inch air-cock at its highest part, with a $\frac{5}{8}$-inch copper pipe leading to bilge.

HYDROKINETERS.

There will be attached to each main boiler two Weir's hydrokineters or other approved device for circulating the water in boiler while raising steam. Each of these to be fitted where directed, and to have a stop-valve close to boiler. They will take steam from the auxiliary steam-pipe—the steam to the pair on each boiler being controlled by a valve in the fire-room.

CIRCULATING TUBES.

Circulating tubes are to be fitted in all main boilers. They will conform to drawings if furnished, otherwise, as may be directed.

ZINC BOILER-PROTECTORS.

Each main boiler will have fourteen rolled zinc blocks 14 x 6 x 1 inches in each boiler, secured as shown in detail drawings.

BOILER CLOTHING.

After the boilers are tested and painted they will be clothed with an approved non-conducting material and covered with approved wire netting.

MAIN FEED-PUMPS.

There will be a main feed-pump in each fire-room, secured to the seatings provided on the starboard side. They will have each two steam and two pump-cylinders, 11 and 6 inches bore

respectively, and 10 inches stroke. They will conform to detail drawings Nos. 1841 and 1852; alterations and additions to crank-shafts and bearings, and alterations in valves, being made as per drawing No. 1853.

Each pump will be connected as follows:

To take steam by a special pipe from the main steam-pipe in same fire-room;

To exhaust into condenser exhaust-system only;

To take suction from feed-tanks and hot-wells only;

To deliver into the main feed-system.

Each pump will have on its delivery side an approved spring pressure-gauge graduated to 180 pounds, and will also have a spring loaded safety-valve of approved dimensions and design, connecting the delivery with the suction side.

AUXILIARY FEED-PUMPS.

There will be on the port side of each fire-room an auxiliary pump, which will be, in construction and fittings, a duplicate of the main feed-pump, but will differ from it in being connected as follows:

Steam from auxiliary steam-pipe;

Exhaust into both auxiliary exhaust-systems;

Suction from sea, hot-wells, feed-tanks, and bilge;

Deliver to auxiliary feed-system and overboard.

There will be a cock at each pump so arranged that the sea suction can never be open to the others. The changes of suction from sea, hot-wells, or bilge-drain will be made by means of a triple valve-box similar to the bilge-suction valve-boxes.

AIR-TIGHT FIRE-ROOMS.

Supplemental bulkheads of light galvanized iron will be fitted, where shown in drawings, for the purpose of reducing the space to be put under air pressure. All permanent and temporary joints are to be made perfectly air-tight. Openings and passage-ways are to be provided where required, with suitable means of closing them.

BLOWERS.

There will be two blowers of 5 feet diameter in each fire-room. They will take air from branches of the fire-room ventilators as shown and will deliver directly into fire-room. They will be made according to detail drawings furnished. Suitable means will be provided for getting at the back bearing of each blower-shaft, as well as means for lubricating the same from fire-room.

BLOWING-ENGINES.

Each blower will be driven by an engine with a 9 x 6-inch cylinder, constructed and supported as shown in drawings. They will take steam from the auxiliary steam-pipe and exhaust into either auxiliary exhaust-system at will. In addition to the steam stop-valves at the engines, there will be in each fire-room a throttle-valve controlling both engines, so arranged as to be easily worked from fire-room floor.

AIR-PRESSURE GAUGES.

An approved gauge will be fitted in each fire-room to show the excess of air pressure over the pressure of the open atmosphere. A portable gauge will also be supplied to each fire-room, which can be connected with the furnaces, uptakes, or where desired to measure the air pressure as compared with the pressure in the fire-rooms.

All these gauges are to indicate pressure in "inches of water."

AUXILIARY BOILER.

There will be on the protective deck, in the compartment provided for it, a cylindrical horizontal return fire-tube boiler for auxiliary purposes. It will be made of the same materials and similar parts will be finished in similar manner as in the main boilers, except that the longitudinal joints will be treble-riveted. The detail drawings will be followed in the construction. Parts not given in detail, including furnace front,

furnace door, ash-pit door, and man-hole plates and fastenings, will be the same as for main boilers, or of other approved design.

AUXILIARY UPTAKE AND SMOKE-PIPE.

The shell of the auxiliary boiler uptake will be constructed similarly to that of main uptakes. The uptake will run from the boiler to the main smoke-pipe, where it will connect with a pipe of 2 feet inside diameter reaching to the top of main pipe.

AUXILIARY BOILER ATTACHMENTS.

The auxiliary boiler will have the following attachments:
One $6\frac{1}{2}$-inch self-acting stop-valve;
One $6\frac{1}{2}$-inch dry-pipe;
One 2-inch check-valve with internal pipe;
One $1\frac{1}{4}$-inch surface blow-valve with internal pipe and dish;
One 2-inch bottom blow-valve with internal pipe;
Two 3-inch safety-valves with lifting gear;
Two steam-gauges;
One glass water-gauge;
Four gauge-cocks;
One sentinel-valve;
One salinometer-pot;
One drain-cock;
One air-cock.
All these to be similar to those for main boilers.

AUXILIARY BILGE AND FIRE-PUMP.

There will be in the forward engine-room, on the port side aft, an auxiliary two-cylinder engine with two double-acting pumps. The steam-cylinders to be 6 x 7 inches and the pump-cylinders $4\frac{1}{2}$ x 7 inches, as per detail drawings of same. The pump will be provided with a suitable spring safety-valve and will have suctions from the following, viz:

From the sea through a valve on side of main injection valve;

From the boilers by the pumping-out pipes;
From the double-bottom valve-boxes;
From the 6-inch bilge-drain;
From the main bilge-drain;
From the forward engine-room bilge;
From the after engine-room bilge.

The sea-suction is to be separated from all others, the same as in auxiliary feed-pumps. This pump will deliver water overboard, to fire-main, to boilers, or to forward engine-room water-service at will.

AUXILIARY FIRE-PUMP.

There will be in the after engine-room, on the port side forward, a duplicate of the auxiliary bilge and fire-pump above specified. The position of this pump is shown on detail drawing No. 1974. It will take suction from the sea only, through a valve on side of main injection-valve chamber, or as otherwise directed. It will deliver only into fire-main and after engine-room water-service.

HAND-PUMPS.

There will be a hand-pump, with plunger $4\frac{1}{4}$ inches diameter, in each engine-room, as per drawings. Each will take water from boilers, 6-inch drain-pipe, or sea, at will; and will deliver into fire-main, main feed-pipes, and overboard, the latter delivery being by an independent pipe and outboard valve. Each pump is to have an additional plunger of 3 inches diameter, with stuffing-box complete, for testing boilers. These pumps are to be fitted in an approved manner to be worked by the main engines when required.

TURNING-ENGINE AND GEAR.

There is to be fitted, where shown, an engine with 6 x 6-inch cylinder, turning, by means of shafting and bevel-gearing, the worm-gearing for turning both main engines. Each

worm-screw is to be fitted as shown, so as to be connected to mesh into the worm-wheel of the main engine when desired. The worm-wheel of the forward engine is to be fitted on the flange-coupling at after-end of crank-shaft as shown; but that of the after engine is to be changed so as to be bolted to the flange-coupling already specified to be placed on forward end of crank-shaft. The end of the first worm-shaft in each engine-room is to be squared, and fitted with a ratchet-wrench of approved design for turning by hand.

ASH-HOISTS.

Each fire-room ventilator is to be arranged to be used for hoisting ashes; suitable doors being provided, as partly shown on drawings, for keeping the fire-rooms air-tight while using the ash-hoists. These doors are to have approved gear for working from fire-room. There will be secured to the athwartship bulkhead of each fire-room a two-cylinder ash-hoisting engine of the type shown in drawings. Each will be fitted with a reversing-gear worked from the door in upper part of either ventilator as shown, and will also have a safety-gear, with adjustable stops, to prevent over-winding. Each engine-shaft will have two drums, one for each ventilator. Each hoist will be fitted with sheave, whip, and appliances for handling ash-buckets complete. Each engine is to be able to hoist 150 pounds with 20 pounds steam-pressure.

ASH-DUMPS.

From each fire-room ventilator, on the upper deck, a permanent overhead-rail, suitably supported, will lead to the ash-chute at the ship's side. Each of these will be provided with a traveler of approved design with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be made with bails pivoted at about the middle of their height, and with proper catches. All the gear to be such that the buckets will not have to be lifted by hand.

STEAM-WINDLASS.

There is to be, in the compartment provided for the purpose, and strongly secured, a steam-windlass, of approved pattern, for handling the anchors. It will have four wildcats for anchor-chain, each to be fitted for 2-inch chain, or as may be directed. The steam cylinders must be of sufficient size, together with the other mechanism, to raise both bower anchors at once at a rate of 6 fathoms per minute with steam of 30 pounds pressure. The engines must be double and have reversing-gear. There will be a drum on both port and starboard ends of windlass, outside the windlass compartment, on upper deck for handling ropes. There will also be a hand-gear, operated from the main deck, for working the windlass. Steam and exhaust connections will be made and all fittings and spare parts supplied complete. The contractors for the hull will make all holes in decks and bulkheads for fitting the windlass and will stow the fittings.

STEAM-WINCH.

There will be, on the upper deck, as shown in the plans furnished to the contractors for the hull, a reversible steam-winch of approved design, for hoisting boats and similar work. It is to have double rope-drums on both port and starboard sides, extending clear of the line of deck-houses. Steam and exhaust connections to be made complete.

DISTILLING-APPARATUS.

One or more distillers, of approved design, will be fitted in the auxiliary boiler-room. They will have a total capacity of 5,000 gallons of potable water per 24 hours, and will be fitted with an efficient filter and with pipes for conveying the fresh water to the various tanks. The distillers will take steam from the auxiliary boiler by an independent pipe and valve, attached to the auxiliary boiler stop-valve chamber under the valve. There will also be a branch connected with

the auxiliary steam-pipe. There will be a pump, of approved design and sufficient capacity, for circulating water through the distillers. It will take water through an independent sea-valve, placed where directed. The water after leaving the distillers will lead forward by a proper pipe and be connected for flushing the crew's water-closets. Branches from this will lead to the officers' water-closets. A bye-pass pipe will be fitted, so that water may pass to the water-closets when the distillers are shut off.

AUXILIARY BOILER FEED-PUMP.

There will be a pump of approved design and of a capacity equal to a No. $2\frac{1}{2}$ Blake pump for feeding the auxiliary boiler. It will have suctions from the sea and from feed-tanks, and will be used for feeding the boiler only.

MAIN STEAM-PIPES.

The main steam-pipes are to lead as shown—one from forward boilers to forward engines, and one from after boilers to after engines, with a connecting-pipe in the hydraulic engine-room. Each branch forward of the connecting-pipe will have a stop-valve, to be worked from the after fire-room and from the main deck, and each branch abaft it a stop-valve in the hydraulic engine-room, to be worked from either main engine-room at will. Branches will lead to main feed-pumps, starting-valves, and reversing-engines.

AUXILIARY STEAM-PIPES.

The principal auxiliary steam-pipe will extend throughout the length of fire and engine-rooms and lead to the auxiliary boiler. There will be a self-acting stop-valve in the pipe, over the forward main boilers, for isolating the auxiliary boiler; this valve to be capable of being worked from the auxiliary boiler-room. There will be, in the hydraulic engine-room, a branch connecting the main and auxiliary steam-pipes, with a stop-valve, shown in detail, worked from below.

Branches will lead to the auxiliary feed-pumps, the main pumping-engines, the circulating-engines, the auxiliary bilge and fire-pump, the fire-pump, the blowers, the ash-hoisting engines, the auxiliary boiler feed-pump, the windlass, the winch, the whistle, the siren, the turning-engines, the radiators, the bottoms of condensers, and the reversing-engines. Branches will also be led to the engineer's work-shop, dynamo-engines, ventilating engines, to the hydraulic engine-room, and to the forward torpedo-room, but the connections will be made by those who furnish the machinery in these places. Stop-valves are to be furnished where shown or where necessary. There will be a steam-gauge in brass case, with about 6-inch dial, attached to the auxiliary steam-pipe, where directed, in each engine-room; also one in each fire-room and one at windlass.

BLEEDER-PIPES.

A branch from each main steam-pipe will lead to the corresponding condenser, with valve as before specified.

RECEIVER LIVE-STEAM PIPE.

A branch from each main steam-pipe will lead to the corresponding receiver, with valve as before specified.

AUXILIARY EXHAUST-PIPES.

The auxiliary exhaust-pipes will be in two separate systems, one discharging into the condensers or the receivers at will, the other discharging into the escape-pipe.

All auxiliary machinery will connect with either exhaust system at will, except where otherwise specified. The windlass, winch, and the pumps in the auxiliary boiler-room will exhaust into the escape-pipe by independent pipes.

The workshop, dynamo, ventilating, hydraulic, and torpedo-engine exhausts will be led, but not connected.

MAIN FEED-PIPES.

The main feed-pipes will lead from each main feed-pump to each main check-valve in the same fire-room. A pipe will connect the two main feed-pipes, with a valve in each fire-room. All these pipes to run overhead and in plain view in each fire-room. An air vessel will be placed in each pipe close to feed-pump; also a copper air-vessel of good capacity, with a glass gauge, a strainer at the bottom, and a cock at the top to draw off the air from the feed-water. This is to be of approved design, or to conform to drawings if furnished. The engine-room fire and bilge-pump and the hand-pumps will deliver into a pipe connecting with the main feed-pipes in after fire-room.

AUXILIARY FEED-PIPES.

A system of pipes will connect the auxiliary feed-pumps with the auxiliary check-valves. These are to be in all respects similar to the main feed-pipe, omitting the air-removing vessel and the engine-room connections.

BOTTOM BLOW-PIPES.

All the bottom blow-valves in each fire-room will discharge through one pipe having an independent outboard valve. Both blows of the auxiliary boiler will connect with the bottom blow in the forward fire-room.

SURFACE BLOW-PIPES.

Each fire-room will have its independent surface blow-pipes and outboard valves similar to the bottom blows.

HOSE-CONNECTIONS.

The auxiliary bilge and fire-pump, the fire-pump, and both hand-pumps will discharge into a fire-main fitted by the contractors for the hull. Standard hose-connections, each with

cap and straightway-valve, are to be fitted to the discharges of these pumps in engine-rooms, also to the discharges of the auxiliary feed-pumps in fire-rooms. There is to be attached to each of these connections a hose of sufficient length to reach to all parts of the compartment in which it is situated, fitted complete with brass coupling, straps, buckles, and nozzles.

WATER SERVICE.

There will be in each engine-room a 3-inch pipe with independent sea connection and with branches leading to the different parts of the engines, as follows: Two to each crank-shaft, crank-pin, and cross-head bearing of main engines, and one to each eccentric; each to be fitted with a detachable spray. One to each line-shaft and thrust-shaft pillow-block, two to each main pumping-engine, and one to each circulating-engine; to be fitted with small hose-connections and short lengths of hose. One to be connected for circulating water through each thrust-bearing. Three branches to each central bearing of crank-shafts and two to each end bearing; these to be screwed into the holes in the pillow-blocks provided for the purpose. Each branch is to have its own valve. The water-service pipe in each engine-room is to be connected with the auxiliary pump in that engine-room, and the two pipe systems are to be connected with each other. All fittings are to be of brass and to follow the detail drawings where shown.

SEA-WATER SUCTION-PIPES.

From a sea-valve in the forward engine-room a pipe will lead to the suction sides of both auxiliary feed-pumps. Other pumps will take sea-water as before specified.

FEED-TANK SUCTION-PIPES.

From the feed-tanks a pipe will lead forward, with branches to the suction sides of all feed-pumps, with valves as required.

HOT-WELL SUCTION-PIPES.

From a valve on each hot-well a pipe will lead to a pipe leading forward, with suction-branches to all feed-pumps in fire-rooms. A branch near each hot-well will lead to a valve on the channel of the air-pump below the foot-valves.

SUCTIONS FROM 12-INCH BILGE-DRAIN.

The auxiliary bilge and fire-pump and both circulating-pumps will have suction-pipes leading to the 12-inch drain-pipe direct.

SUCTIONS FROM 6-INCH BILGE-DRAIN.

Each hand-pump, and the auxiliary bilge and fire-pump, will have a direct suction from the 6-inch drain-pipe.

SUCTIONS FROM BILGE VALVE-BOXES.

Each main bilge-pump will have a suction-pipe from the bilge valve-boxes in the same engine-room, and the auxiliary bilge and fire-pump from the valve-boxes in both engine-rooms.

SUCTIONS FROM DOUBLE-BOTTOM VALVE-BOXES.

The forward main bilge-pump and the auxiliary bilge and fire-pump will have suction-pipes from the double-bottom valve-boxes. A branch will lead from these pipes to a sea-valve, used for this purpose only, for filling the double bottom.

DIRECT BILGE-SUCTIONS.

In addition to the bilge injections before specified, there will be direct bilge-suctions in each fire-room to the auxiliary feed-pump, and in each engine-room to the main bilge-pump, and from both engine-rooms to the auxiliary bilge and fire-pump. Each of these suction-pipes will take from the lowest

part of the bilge or from a cistern without a strainer, and will be provided, above the floors, with a Macomb bilge-strainer. Each pipe will also have a screw check-valve in an accessible position.

BOILER PUMPING-OUT PIPES.

A system of pipes will lead from the pumping-out valves on the main boilers to both hand-pumps and to the auxiliary bilge and fire-pump.

ESCAPE-PIPES.

There will be an escape-pipe abaft the smoke-pipe leading to the top of the latter. It will have branches leading to all safety-valves and to the auxiliary exhaust system before specified, and will be fitted with a muffler.

SEPARATORS.

There will be in each main steam-pipe in its own engine-room, and in the auxiliary steam-pipe in the hydraulic engine-room, a separator, of composition, as shown in detail drawings, properly supported. Each will be fitted with a glass gauge of approved pattern; also with an approved steam-trap with drains leading to the sea or to feed-tanks at will.

PIPE-CLOTHING.

All steam-pipes, exhaust-pipes where directed, the separators, and all steam-valves are to be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas in double thickness, well painted. The covering to be secured to bulkheads where pipes pass through them. These pipes are also to be covered with black-walnut lagging, with brass bands, where directed.

PIPES THROUGH BULKHEADS.

Where pipes pass through bulkheads they will have flanges bolted to bulkheads, be provided with stuffing-boxes, or be made tight in other approved manner.

MATERIAL AND FITTING OF PIPES.

All pipes, except the lower parts of bilge-suction pipes, unless otherwise specified, are to be of copper. All feed and blow-pipes and all bilge-pipes, except the lower parts, are to be of seamless-drawn copper. All copper pipes not seamless-drawn are to be brazed. All copper pipes are to have composition flanges riveted on, calked, and brazed. All flanges are to be faced and grooved, and joints are to be made with red lead, without sheet-lead or canvas. All flanges below the floor-plates are to be connected by Tobin's metal bolts and nuts. All copper pipes in bilges are to be well painted and covered with waterproof canvas, and must not rest in contact with any of the iron or steel-work of the vessel. All bends in copper pipes are to be made one gauge thicker than straight parts. All copper pipe T-pieces and fittings are to be made of composition. Expansion-joints, of patterns shown, are to be fitted where shown in drawings; also elsewhere, as may be needed. The lower parts of bilge-suction pipes are to be of galvanized iron.

SIZES AND THICKNESS OF PIPES.

The sizes and thickness of pipes are to conform to those given in the list of pipes accompanying the drawings. Such pipes as are not there given will be of approved size and thickness.

DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and cocks or valves of ample size, and with approved automatic traps which will discharge into feed-tanks and bilge, or as directed. The discharges from the drain-traps of the low-pressure cylinders and valve-chests and from the receiver will lead into the condenser and the bilge. All drain-cocks will have their handles pointing downward when closed. All traps are to have bye-pass pipes and valves for convenience of overhauling.

AUXILIARY ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close as possible to the cylinders, and all pumps will have screw check-valves in both suction and delivery pipes close to pumps. Exhaust stop-valves are to be straightway when practicable.

SEA-VALVES.

There will be in the various compartments sea-valves as follows:

In after engine-room:

Main injection, with jet-injection and auxiliary pump-suction attached;

Main bilge discharge;

Main outboard delivery;

Air-pump delivery, with main bilge-pump discharge attached;

Hand-pump delivery overboard;

Sea-valve of engine-room water-service.

In forward engine-room:

Duplicates of the valves in after engine-room, and also the following:

Main sea-suction, with branches to auxiliary feed-pumps and to pipe for filling compartments of double bottom;

Auxiliary bilge and fire-pump delivery overboard;

In after fire-room:

Bottom blow Kingston;

Surface blow Kingston;

Auxiliary feed-pump delivery overboard.

In forward fire-room:

The same as in after fire-room.

There will also be a sea-valve for suction to the distiller-pump, located in such position as may be directed. All sea-valves not otherwise specified or shown in drawings will be of the Kingston pattern. All sea-valves will be above the

double bottom. The blow Kingstons will have stop-valves close inboard of them, with stems to work from fire-rooms. All Kingston valves are to have their spindles cast on, and are to be proved by tensile strain of half a ton to every square inch of the area of the valves. No waste-water is to be delivered above the water-line. All sea-suction valves are to have gratings on the out-side of the vessel similar to that shown for the main injection-valve. All valves not shown in detail are to have clear openings equal to the combined areas of the connecting-pipes.

ATTACHMENT OF VALVES TO HULL.

The openings in hull for the attachment of valves over 6 inches diameter will be rectangular, and valve-nozzles will be made to correspond. These valves will be attached to the hull in a similar manner to the main-injection Kingston. Valves of 6 inches diameter and less will be attached similarly to the 6-inch Kingston shown in detail.

PLUGS FOR DISCHARGE OPENINGS.

A composition plug with India-rubber joint, as shown in drawings, is to be fitted to each discharge-opening, to be put in or taken out by means of a lever on the ship's side above the water-line. The outriggers on the ship's side are to be complete with all levers and gears.

BILGE–SUCTION VALVE–BOXES.

The bilge and double-bottom suction valve-boxes and valves are to be supplied by the engine contractors, who will also connect them with the pumps, but the connections to them from the 12-inch and 6-inch bilge-drains and from the forward and after compartments will be made by the hull contractors. There is to be a separate valve for each suction, and they are all to be plainly marked to show their use. The valve-boxes are to be made of composition, and not of cast-iron as shown in drawings.

COCKS AND VALVES.

All cocks and valves and their fittings, unless otherwise specified, including all hand-wheels, are to be made of composition. All cocks communicating with vacuum spaces are to have bottoms of shells cast in and to have packed plugs. All cocks above 1 inch in diameter are to have packed plugs. All gland-studs of cocks or valves attached to the hull or under the floor-plates are to be of copper. Valves of approved pattern are to be supplied wherever necessary to complete the various pipe systems, whether shown in drawings or not. Cocks and valves may, where directed, have, in lieu of wheels or permanent handles, movable box or socket-wrenches, marked and stowed where directed. All valve-wheels are to turn right-handed to close.

LABELS ON COCKS AND VALVES.

All cocks are to have engraved brass plates to show their use and to indicate whether open or shut. All valves, except such as may be directed, are to have similarly engraved plates to show their use, or have the same plainly engraved on hand-wheels.

WHISTLE.

A composition steam-whistle, with bell of 6 inches diameter, is to be placed forward of the smoke-pipe, well above the level of the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at the upper end.

SIREN.

There is to be a steam-siren of approved pattern and size, placed and connected similarly to the whistle.

RADIATORS.

Radiators or heating-coils of approved pattern, divided and placed where directed, will be furnished, fitted, and connected, with superficial areas as follows:

For the cabin, 80 square feet;
For the ward-room, 32 square feet;
For the steerage, 34 square feet;
For the ward-room country, 185 square feet;
For the crew's quarters, 315 square feet;
For the sick-bay, 16 square feet;
For the chart-house, 7 square feet;
For the wheel-house, 16 square feet.

Each radiator or coil, unless otherwise directed, is to be divided into two parts, each with its own steam and drain-valve. The steam and drain-pipes are to be of seamless drawn brass, iron-pipe size, suitably connected by composition fittings in a manner that will enable them to be easily taken down for repairs. The steam-pipes will connect with the auxiliary steam-pipe in the auxiliary boiler-room and will be fitted with adjustable reducing-valves. The drain-pipe of each circuit will have an approved steam-trap discharging into the feed-tanks, and elsewhere as may be directed.

SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be provided with stuffing-boxes.

FLOOR-PLATES.

The engine-rooms, fire-rooms, auxiliary boiler-room, and connecting passages are to be floored with wrought-iron about ¼-inch thick with neatly matched narrow corrugations running fore and aft. The plates are to be of convenient size and easily removable. They will rest on proper ledges and will have drain-holes where necessary. Proper platforms will

be provided for getting at all parts of the main and auxiliary engines and boilers. These platforms where placed over moving machinery will be fitted the same as the lower floors. In other places they will be made of iron rods $\frac{5}{8}$-inch square spaced $\frac{3}{4}$-inch apart.

LADDERS.

Ladders will be fitted wherever necessary for reaching the engine-rooms and fire-rooms from deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladders will be made with plate-iron sides and light cast-iron treads with corrugated tops. The fire-room ladders will be made with plate-iron sides and double square bar treads. All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing the battle-hatches. Ladders will be fitted to and through engine-room ventilators as means of egress when the battle-hatches are closed. Suitable means of egress from fire-rooms will also be provided without passing through the air-locks

HAND-RAILS.

Finished brass hand-rails with finished wrought-iron stanchions, easily removable where necessary, will be fitted to all ladders and platforms and around all moving parts of machinery and along bulkheads and passageways.

ENGINE-ROOM INSTRUMENTS.

Each engine-room will be fitted with the following, in full view of the working-platform, and properly lighted:

One Lane's improved spring steam-gauge, connected to the main steam-pipe.

One Lane's improved spring compound-gauge, connected to the receiver.

One approved spring vacuum-gauge, connected to the condenser.

One eight-day clock with second-hand.

One continuous rotary-counter with positive motion, to register from 1 to 1,000,000.

Two revolution-indicators, showing on suitable dials the speed of both screw-engines.

One telegraph-dial.

Four thermometers, viz: one for feed-water, one for injection-water, one for discharge-water, and one for steam in main steam-pipe. These thermometers, if directed, will be placed close to their parts of the engines instead of on the working-platform.

There will be on each circulating-engine and on each air-pump engine a counter or a revolution-indicator, as may be directed; and on each condenser a mercurial vacuum-gauge.

Each working-platform will be fitted with telegraphs and speaking-tubes leading to engine-rooms, fire-rooms, wheel-house, deck, and where directed.

Each engine-room will be furnished with four Thompson indicators of standard size, of the latest pattern made by the American Steam-Gauge Company; each to be fitted with a spring of 40 pounds to the inch and one of 16 pounds, with proper attachments, all nickel-plated. Also one extra cock attachment for each indicator. Each indicator to be in its own case and to be suitably marked. Cases to be conveniently stowed.

All gauges, clocks, and counters, to have dials of at least $8\frac{1}{2}$ inches in diameter. All fittings to be of polished brass.

ENGINE-ROOM LOG-DESKS.

A desk of approved pattern with locked drawer, is to be fitted in each engine-room where directed.

INDICATOR FITTINGS AND MOTIONS.

An indicator connection is to be made to each end of each steam-cylinder of the main, air-pump, and circulating-engines, and to each end of each air-pump as near as possible to the

bores of the cylinders and so as to be easily accessible. Each indicator, when in place, is to be connected to but one end of a cylinder. The connecting pipes are to be of 1-inch bore and without bends. The indicator motion of each engine is to be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels are to be coincident with the motions of the corresponding pistons.

All steam-cylinders of engines not above specified are to have holes tapped for indicator fittings, and the holes plugged; the corresponding engines are to have portable indicator motions fitted; then removed and suitably stowed.

ENGINE-ROOM TELEGRAPHS.

A repeating telegraph of approved pattern is to be fitted in each engine-room and connected to transmitters in conning-tower, in wheel-house, and on bridge. The connections are to be made in such a manner that the chance of derangement shall be minimized.

SPEAKING-TUBES.

Speaking-tubes, fitted where directed, will be made of copper not less than No. 20 B. W. G. Each tube will be fitted at each end with a mouth-piece and approved annunciator. The tubes will be suitably cased where necessary.

REVOLUTION-INDICATORS.

Revolution-indicators are to be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices.

TELL-TALES.

Tell-tales with proper connections are to be fitted on the bridge and in the conning-tower to show the directions of motion of the propelling-engines.

GOVERNORS.

An efficient governor of approved type, with all necessary connections, is to be fitted to each propelling-engine.

LUBRICATION.

All working parts of machinery are to be fitted with efficient lubricators, with capacity for sufficient oil for four hours' running. All moving parts of the propelling, air-pump, circulating-pump, main feed-pump, and blower-engines are to have approved automatic oiling devices, so that they may be lubricated without slowing. All fixed oil-cups will have hinged covers. Moving oil-cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated.

There is to be fitted at the highest parts of main valve-chests, directly over each steam port, a globe or pump oil-cup with the necessary valves and pipes; also, one similar cup to each valve-chest of other engines. There will be fitted to each main steam-pipe, close to main valve-chest, a Siebert (or equivalent) sight-feed oil-cup of two quarts capacity. Also, smaller sight-feed cups are to be fitted to each air-pump, circulating-pump, main feed-pump, and blower-engine. All sight-feed cups are to have ample condensing surface on their steam-pipes. All oil-cups and their fittings, except such as are cast on bearings, are to be of finished cast-brass.

OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible; otherwise they will be of cast-brass and properly applied. All moving parts will have drip-cups or pans, cast in engine-

frames when possible; otherwise to be made of sheet-brass. The oil from all drip-cups on each main engine is to run into a larger reservoir, fitted with a small hand-pump, so that the contents may be pumped out while the engines are at work.

ASH-SPRINKLERS.

A cock for wetting down ashes will be fitted in each fire-room as shown, and will be supplied with all necessary hose and nozzles.

JOURNAL-BOXES.

All journals, or moving parts of iron or steel, unless otherwise specified or shown in drawings, are to run in composition boxes. These boxes are to be lined with approved anti-friction metal where shown in drawings.

STUFFING-BOXES.

All iron stuffing-boxes are to have composition bushings. All glands are to be of composition. All gland-nuts on stuffing-boxes of propelling and air-pump engines, and of air-pumps and main bilge-pumps, will be fitted with pinions and spur rings. All glands not so fitted will have lock-nuts on their studs.

PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, are to be made of composition.

BOLTS AND NUTS.

All bolts and nuts are to conform, except in special cases, to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except where directed, are to be prevented from turning, by dowels or other suitable devices. All bolts on mov-

ing parts and on pillow-blocks, except where otherwise shown, will be fitted with lock-nuts, and the bolts will extend beyond the nuts, without threads; will be finished with rounded ends and fitted with split-pins.

SUPPORTS FOR LAMPS.

Approved supports for lamps will be fitted where directed.

GEAR FOR WORKING VALVES FROM DECK.

The gears for working, from deck, the safety-valves, main steam-pipe stop-valves, and engine stop-valves will each be fitted with a hand-wheel. The stop-valve hand-wheels will be about 16 inches in diameter, and those for the safety-valves about 10 inches. The wheels will be made of finished brass and will have their rims connected to the hubs by plain disks without holes in them. The rims will have radial holes for the insertion of pins to assist in turning. The standards will be cast of composition, left rough, and painted.

LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turn-buckles, shackles, hooks, eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

OIL-TANKS.

Four oil-tanks of 200 gallons capacity each will be fitted where directed, with facilities for filling from deck. They will be made of wrought-iron not less than $\frac{1}{8}$-inch thick, and each will have a man-hole and cover near the top and a locked cock for drawing oil. In each engine-room there will be fitted two copper oil-tanks of 16 gallons each, and two of 6 gallons each, and in each fire-room one of 5 gallons; all with locked cocks. All oil-tanks will be fitted with drip-pans.

An iron tallow-tank of 100 pounds capacity, with hinged cover, is to be fitted where required.

VENTILATORS.

Ventilators and fittings, two for each engine-room, two to each fire-room, and four for uptake-rooms, as shown in drawings, are to be supplied. The ventilator-shafts are to be of wrought-iron, and the cowls of copper, not planished, with cast composition base-rings finished on the inside but left unfinished on the outside. The engine-room ventilator-cowls are to be fitted to be worked from below and the others from above. The gear for revolving cowls is to be of composition, except the spindles running to engine-rooms. The hand-wheels on deck are to be of polished brass, and in the engine-room may be the same or may be replaced by wrought-iron T-handles, as may be directed. The fire-room ventilators to be fitted with proper doors at the upper deck and to be otherwise fitted as before specified to be used for hoisting ashes; also to be so fitted that they may be used without the blowers for natural draught.

SMOKE-PIPE COVER.

A smoke-pipe cover, in two parts as shown, is to be fitted and to be securely stowed in a convenient place. Each part is to be fitted with eye-bolts and shackles for lifting by.

INSTRUMENTS AND TOOLS.

The following instruments and tools are to be furnished in addition to such as are elsewhere specified, viz:

Two Thompson indicators of same kind as furnished for main engines, each in its own case, with fittings complete.

Two spare water-thermometers.

Two spare steam-thermometers.

One standardized thermometer in suitable case, with certificate of standardization.

Two complete sets of fire-tools for each fire-room, stowed in suitable racks.

Lazy-bars for all furnaces, fitted in place.

One set of wrenches complete for each engine-room and each fire-room, to be fitted to all nuts in their respective compartments, finished, and marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of all bolts over 2 inches diameter are to be box-wrenches, where such can be used. Socket-wrenches to be furnished where required.

One pair of taps, on rod, for tapping front and back tube-sheets of boilers at one operation. This is to be a duplicate of that used in originally tapping the sheets, and is to be so packed as to be perfectly protected from injury.

Two steam tube-cleaners, one for each fire-room, of approved design, with fittings and connections complete. They are to be of sufficient length to clean the tubes from the fire-room ends through furnaces or ash-pits. Each to be fitted with a wooden handle and to be stowed in a convenient rack in fire-room. A spare nozzle and flexible steam-hose is to be furnished with each.

A fixed trammel for setting the main piston-valves without removing covers; the valve-stems to be properly marked for this purpose.

A fixed trammel for each radius-link of valve-gear, for setting the centers at the proper distances.

A fixed trammel or gauge for each end of each crank-shaft, for gauging the height of shafts—brass pins being let into the bed-plates and center-marked for this purpose.

All the above-mentioned trammels to be stowed in suitable cases, so as to be protected from injury.

DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, are to be furnished, fitted, and ready for use, viz:

One set of valves for each steam-pump;

One seat, with guards and bolts complete, for receiving-valves, and one for delivery-valves of air-pumps;

One-half set of follower-bolts and nuts for each steam-piston, and one for each air-pump piston;

One-half set of springs for each steam-piston;

One set of brasses for each crank-shaft journal;
One set of brasses for each crank-pin journal;
One set of brasses for each cross-head journal;
One cast-iron shoe for each cross-head;
One set of brasses for each thrust-bearing;
Two hundred condenser-tubes packed in boxes;
One hundred stay-tubes, threaded to fit threads in tube-sheets, and 300 plain boiler-tubes, swelled at one end and annealed. The ends of stay-tubes to be wrapped in canvas. All boiler-tubes to be securely stowed in racks or as directed;
One hundred stay-tube nuts;
One spare basket for each Macomb bilge-strainer;
One-eighth of a set of grate-bars;
A complete set of brasses for each main-engine valve-gear;
A complete set of cup-leathers for hydraulic cylinders of reversing-engines.

All duplicate pieces not of brass are to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with the name marked in black paint on the outside. Brass pieces are to be marked or stamped.

SECURING ENGINES IN SHIP.

The engines will be secured to their seatings as shown in such drawings as may be furnished. If no drawings are furnished the following method will be adopted:

The engines will be adjusted and lined upon the engine-seatings by means of hard wooden wedges driven from both sides of the bearing surfaces, and when accurately in line the spaces around the holding-down bolts between sole-plates and engine-seatings will be filled by accurately fitting wrought-iron horse-shoe washers, upon which the holding-down bolts will be set up and their nuts locked in place.

MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale and all fins and roughness removed.

No imperfect or unsound casting or forging will be used if the defect affects the strength, or, to a marked degree, its sightliness.

All nuts on rough castings are to fit facings raised above the surface. All flanges of castings are to be faced, and those coupled together are to have their edges made fair with each other. The facings of all circular flanges of castings are to be grooved.

All bolt-holes in permanently fixed parts are to be reamed, or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All threads on bolts and nuts are to be of the United States Navy standard. All pipes beneath floor-plates are to be connected by forged bolts and nuts of Tobin's metal.

All brasses are to fit loosely between collars of shafting.

All brasses or journals are to be properly channeled for the distribution of oil. Packing for stuffing-boxes to be such as may be approved.

All small pins of working parts are to be well case-hardened.

All materials used in the construction of the machinery are to be of the best quality. The iron castings are to be made of the best pig-iron, not scrap.

Composition castings are to be made of new materials. For all journal-boxes and guide-gibs, where not otherwise specified, the composition is to be, by weight:

Copper, 6 parts.
Tin, 1 part.
Zinc, $\frac{1}{4}$ "

Where Tobin's metal is specified the composition will be:

Copper, 58.22 %
Tin, 2.30 "
Zinc, 39.48 "

For other composition the proportions will be:

Copper, 88%
Tin, 10 "
Zinc, 2 "

Ornamental brass fittings to be of uniform color.

All boiler-plates are to be well cleaned of oxide-of-iron scale.

All flanged parts of boilers are to be annealed after flanging, in an approved manner.

The contractors for the hull will supply the labor to fit the seatings to the engines, boilers, and auxiliaries.

All parts of machinery and boilers are to be secured in an approved manner to prevent displacement when the vessel is used for ramming.

All work is to be in every respect of the first quality and executed in a workmanlike and substantial manner. Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

TESTS OF MATERIALS.

All materials used in the construction of the boilers, shafting, and steel castings, will be tested in accordance with the "Instructions to Inspectors," a copy of which is appended to these specifications. All boiler and condenser-tubes must be tested to 300 pounds internal water-pressure before being put into boilers and condensers. India-rubber valves are to be of the best Para caoutchouc, and to be of homogeneous character. Valves taken at random are to stand a dry-heat test of 270° F. for one hour, and a moist-heat test of 320° F. for three hours, without the quality being impaired.

TESTS OF BOILERS AND MACHINERY.

Before the boilers are painted or placed in the vessel they will be tested under a pressure of 180 pounds per square inch above atmospheric pressure. This pressure is to be obtained

by the application of heat to water within the boilers, the water filling the boilers quite full.

Each high-pressure cylinder and valve-chest, the auxiliary engines, and all steam-jackets, pipes, and connections subjected to the boiler-pressure are to be tested by water-pressure to 180 pounds to the square inch; the low-pressure cylinder and the receiver to 60 pounds, and the steam side of the condenser to 30 pounds. The feed-tanks and all remaining parts are to be tested to 15 pounds per square inch. The cylinders and condensers are to be tested by water-pressure before being placed on board, and so placed that all parts may be accessible for examination by the Inspector during the test. No lagging or covering is to be on the cylinders or condensers during the test.

PAINTING.

After a satisfactory test the boilers are to be painted on the outside with two coats of brown zinc and oil. All engine-work not finished to be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color.

The shafting is to be painted, when in place, with two coats of white lead and oil, and the boiler fronts with two coats of lamp-black and oil. The smoke-pipe is to be thoroughly painted, both before and after erection on board the vessel.

The ventilators and cowls will be painted similarly to the smoke-pipe, except the interiors of cowls, which will be painted vermilion.

All steam-pipes not lagged will be painted white; exhaust-pipes, green; water-supply pipes, red; and water-discharge-pipes, lead-color.

PRELIMINARY TESTS AND TRIALS.

While the engines and boilers are being completed steam will be raised in the boilers whenever required to test the connections, the working of all parts of the main engines and boilers, and all auxiliaries. All expense of such preliminary tests will be borne by the contractor.

INSPECTOR'S OFFICE.

A suitable office and draughting-room, properly fitted and heated, for the use of the Inspector of Machinery and his assistants during the building of the machinery, is to be furnished by the contractor.

RECORDS OF WEIGHTS.

All materials and parts of the machinery must be carefully weighed by the contractor when ready to go on board the vessel, and a record of the weights in detail furnished to the Inspector, certified to by him, and reported to the Bureau of Steam Engineering.

WORKING-DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor. Those which are merely developments of the drawings furnished and of these specifications must be subject to the approval of the Engineer-in-Chief or of the Inspector of Machinery, as may be directed, before the work is ordered or commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings or between drawings and specifications will be referred to the Inspector of Machinery, who will keep a record of the same, together with his decisions, and forward it to the Bureau of Steam Engineering.

CHANGES IN PLANS.

The contractor must make no changes from the drawings furnished, except as may be herein directed, or from the provisions of these specifications without preparing complete plans of such proposed changes and submitting the same to the Engineer-in-Chief for approval.

DRAWINGS OF COMPLETED MACHINERY.

A complete set of drawings of the machinery, as fitted, must be furnished by the contractor, certified to by the Inspector of Machinery, and forwarded to the Bureau of Steam Engineering immediately upon completion of the work.

OMISSIONS.

The engines, boilers, uptakes, and smoke-pipe, all auxiliaries, their piping and connections, and all sea-valves, except the cutting of the holes for the same, and all parts described in these specifications and the official drawings, are to be fitted complete to the vessel by the engine contractors, and any part of the machinery, or any article pertaining thereto, which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor, without extra charge.

TESTS OF STEEL FOR CRUISERS.

INSTRUCTIONS TO INSPECTORS.

The following rules are prescribed in order to insure the fulfillment of the clause of the Act of Congress of August 5, 1882: "Such vessels * * * to be constructed of steel of domestic manufacture, having as near as may be a tensile strength of not less than sixty thousand pounds to the square inch, and a ductility in eight inches of not less than twenty-five per centum."

I. All ship-plates, beams, angles, rivets, bolts, boiler-plates, and stays are to be inspected and tested at the place of manufacture by a Naval Inspector of Material, and to be passed by him, subject to restrictions hereinafter mentioned, before acceptance by the ship-builders, whether Government or private, for incorporation into said vessels.

II. Every plate, beam, and angle supplied for these vessels is to be clearly and indelibly stamped in two places, and with two separate brands: 1st. With that of the maker, which shall distinguish the name of the manufactory or company; 2d. With the regulation brand of the Naval Inspector of Material. The latter not to be stamped upon any of the above-mentioned material until it shall have passed an inspection for surface or other defects of manufacture and the physical tests have been accepted by the Inspector and have been stamped with the maker's brand.

In case of small artícles passed in bulk the above-mentioned brands shall be applied to the boxing or packing material of the objects.

No steel material to be received at the building yards for incorporation into vessels except it bear, either upon its surface or that of its packing, both of these brands as evidence that it has passed the necessary Government inspection.

III. The weight of all plates, beams, angles, &c., must be obtained by the Inspector of Material before delivery.

Plates of 12½ lbs. per square foot or less, and strips and bars of 6 lbs. per lineal foot or less, may be accepted if the weights vary between 3 per cent. above and 5 per cent. below the specified weights.

All other plates and shapes may be accepted if the weights vary between the specified weights and 5 per cent. below them.

All plates and shapes not being within the limits here specified may be rejected.

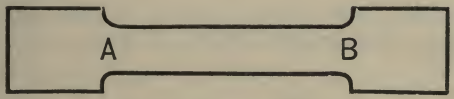
TESTS.

All material except boiler-plates should be tested by heats as follows:

A specimen ingot or bloom shall be selected and rolled into a plate or bar and test pieces cut therefrom, provided always that the test pieces shall have received no more working than that which the finished material from the heat would receive.

Four test pieces, of the form shown in Fig. 1, for plates, (square or round, in condition as finished at the rolls, may be used for the tests of shapes,) shall be made and tested for each heat.

Fig. 1.



The length A B must be at least 8 inches of uniform cross-section of which the area should not be less than $\frac{1}{2}$ nor more than $\frac{8}{10}$ of one square inch.

The reduction of width throughout the length A B should be just sufficient to prevent failure in the grips.

The test pieces must not be annealed unless the finished material is to be annealed.

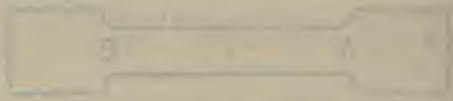
Each test piece shall be submitted to a direct tensile stress until it breaks, in a machine of approved character.

The initial stress to be 30,000 pounds per square inch.

The first load to be kept in continuous action for one minute.

An observation to be made of the corresponding elongation measured upon the original length of 8 inches.

The stress then to be increased slowly until the principal elastic limit is determined, after which additional loads will be added at intervals of time nearly as possible equal, and separated by half a minute, the loads to produce an increase of stress of 5,000 pounds per square inch of original section of the test piece until the stress is about 50,000 pounds per square inch of original section, when incre-



ments of stress should not exceed 1,000 pounds per square inch. Upon close approach to the possible ultimate strength the load to be increased gradually and its maximum value carefully noted.

The final elongation to be that obtained after rupture.

A list of all ingots made from each heat must be supplied to the Inspector. Each ingot should be stamped in his presence with the number of the heat. He should also see the test plate or billet cut off, stamped, and rolled, and place a private stamp upon it in such a way that each test piece will have the impression of the stamp near one end.

CONDITIONS OF ACCEPTANCE.

In order to be accepted the average of the four test pieces must show an ultimate tensile strength of at least 60,000 pounds per square inch of original section, and a final elongation in 8 inches of not less than 25 per centum.

Material which shows a strength greater than 60,000 pounds per square inch will be accepted, provided the ductility remains at least 23 per centum.

CASES OF FAILURE.

If the average of these four test pieces, numbered 1, 2, 3, and 4, (called Test I,) fall below either of the required limits, the ingot from which pieces 1, 2, 3, and 4 were cut shall be rejected, and Test II made, consisting of pieces 5 and 6 cut from a second ingot; if the mean of the results of these two fall below either of the above limits the entire lot shall be rejected. If it be successful Test III, or the mean of pieces 7 and 8 cut from a third ingot, shall decide.

If in any of the Tests I, II, III, any single piece shows a tensile strength less than 58,000 pounds, or a final elongation less than 21 per cent., the ingot from which it was taken shall be rejected and that test considered to have failed, regardless of its average.

QUENCHING TEST.

IV. A test piece shall be cut from each plate, angle, or beam, and after heating to a cherry-red plunged in water at a temperature of 82° Fahrenheit. Thus prepared it must be possible to bend the pieces under a press or hammer so that they shall be doubled round a curve of which the diameter is not more than one and a half times the thickness of the plates tested, without presenting any trace of cracking.

These test pieces must not have their sheared sides rounded off, the only treatment permitted being the taking off the sharpness of the edges with a fine file.

Inspectors may require a cold-bending test when considered necessary.

ANGLES, BEAMS, BULB-BARS, T-BARS, ETC.

V. Angle-bars are to be subjected to the following additional tests: A piece cut from one bar in twenty to be opened out flat, while cold, under the hammer; a piece cut from another bar in the same lot shall be closed until the two sides touch, while cold.

Bulb and T-bars are to be submitted to a closing test similar to that prescribed for angle-bars.

Bars submitted to these tests must show neither cracks, clifts, nor flaws.

RIVETS.

Each 1,000 lbs. of rivets from the same heat of metal shall constitute a lot, and be accompanied by two sample bars, each 18 inches long, for tensile test. These samples for tensile test shall be cut from the bars from which the lot of rivets is made, and be stamped with a number which shall also be placed on each box or package of that lot.

These samples to be subject to the same tensile test as that required for the plates.

The lot of rivets from which this sample bar does not fulfill the requirements of tensile strength and elongation required for plates, is to be rejected.

From each lot, six rivets are to be taken at random and submitted to the following tests, two rivets to be used for each test: 1st. Two rivets to be flattened out cold under the hammer to a thickness of one-half the diameter, without showing cracks or flaws. 2d. Two rivets to be flattened out hot under the hammer to a thickness one-third the diameter, without showing cracks or flaws. 3d. Two rivets to be bent cold into the form of a hook with parallel sides, without showing cracks or flaws.

BOILER MATERIAL.

Two tensile test pieces shall be cut from each plate rolled for boilers; and one quenching test piece, which shall be tested as before described, except that, in the tensile tests, the initial stress may be 25,000 lbs. to the square inch.

The limits of strength for all plates, braces, stays, angles, and T-bars, shall be as follows:

The ductility in eight inches must not be less than 25 per centum, and the ultimate tensile strength must not be less than 57,000 lbs. and not more than 63,000 lbs.; and no single piece must show a less tensile strength than 57,000 lbs. to the square inch, except plates for flanging and those used in the construction of the furnaces, which will have an ultimate tensile strength of not less than 50,000 and of not more than 55,000 lbs., and a ductility in eight inches of not less than 29 per cent.

No steel for boilers which is to be worked at a heat or to be annealed after working in the boiler-shops, shall be annealed at the works.

The acceptance of material under these tests will not relieve the contractor from the necessity of making good any material which fails in working or may be rejected by the Inspector.

TEST OF STEEL SHAFTS.

1. Each length of rough-forged shaft should have a piece cut from it, at that end which was uppermost in the ingot, of sufficient size to allow the removal of specimens for tensile test, parallel with the axis of the shaft, having a measured length of 4 inches between reference marks and of $\frac{1}{4}$ square inch sectional area when finished.

2. From the piece so removed, four test-pieces shall be taken, two at circumference of finished diameter and two at $\frac{1}{2}$ radius from center. These pieces to be broken in a machine of approved character, under the same conditions as prescribed for "Tests of Steel for Cruisers."

3. The ultimate tensile strength of the four pieces must be within the limits of 26 and 30 tons (of 2240 lbs.) per square inch, and that of no single piece may fall below 25 tons. Pieces showing greater tensile strength than 30 tons will be accepted, provided the required ductility and other tests are satisfied.

The ductility of no piece at outer radius may be less than 20 per cent., and that of no piece at inner radius less than 16 per cent., in the measured length of 4 inches.

4. Bars $\frac{1}{2}$-inch thick, cut at the outer radius, must stand bending double to an inner diameter of $1\frac{1}{2}$ inches after common quenching in water from a low cherry-red temperature.

5. Pieces cut from the rough-forged shaft for test may not be subjected to any subsequent treatment or process.

6. Inspectors of steel shafting shall have full facilities to assure themselves of the general good quality of the metal and of a satisfactory method of manufacture, and may reject any piece considered to be defective in quality or fabrication, without regard to the prescribed tests.

TEST OF STEEL CASTINGS.

All steel castings are to satisfy the following conditions:

Tensile strength to be between 60,000 and 70,000 pounds per square inch of cross-section.

Extension in 8 inches of length to be at least 10 per cent.

Bars of the same metal 1 inch square should be capable of bending cold without fracture through an angle of 90° over a radius not greater than $1\frac{5}{8}$ inches. Test pieces are to be taken from each important casting.